ADDIS ABABA SCIENCE AND TECHNOLOGY UNIVERSITY
COLLEGE OF ARCHITECTURE AND CIVIL ENGINEERING

COMPARATIVE STUDY OF ECONOMICAL DESIGN ASPECT OF REINFORCED CONCRETE T-GIRDER WITH BOX-GIRDER BRIDGES

A Project in Structural Engineering

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A Project Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Engineering in structural engineering

The undersigned have examined the Project entitled 'Comparative study of Economical Design aspect of Reinforced Concrete T-Girder with Box Girder Bridges' presented by **Degera Gezahegn**, a candidate for the degree of **Master of Engineering** and hereby certify that it is worthy of acceptance.

Internal Examiner	Signature	Date
External Examiner	Signature	Date
Chair person	Signature	Date

UNDERTAKING

I certify that research work titled "Comparative study of Economical Design aspect of Reinforced Concrete T-Girder with Box Girder Bridges" is my own work. The work has not been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged / referred.

Signature of Student

Degera Gezahegn

ABSTRACT

The purpose of present study is the design to exploring the economic analysis for superstructure for different span length both for reinforced concrete T- girder and Box girder bridge super structures. The analysis and design is done under Ethiopia Road Authority (ERA) and (AASHTO) loading for selection of most economical section for different span length of super structures. In present study a two lane simply supported Reinforced concrete T-girder and Box-girder Bridge was analyses for dead load and moving load. The dead load calculation has been done manually and for live load linear analysis is done on SAP2000V14.

In normal ground conditions, reinforced concrete T- girder bridge structure is more economical than Box girder bridge for shorter span(12m to 20m) and Box girder bridge's more economical for longer span(15m to 36m).

The present paper will facilitate as a hand on tool for selection of economical superstructure type for 14m, 18m, 24m, 30m,and 34m span length bridges. The present study aims to develop an economic solution for construction of superstructure for different span bridge under Ethiopia Road Authority (ERA) and (AASHTO) loading.

A comparative study on the basis of cost of materials (construction cost) is conducted to select and identify the economical span range of T-girder and Box-girder bridges.

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CHAPTER 1 INTRODUCTION

1.1 Background

Bridge is life line of road network, both in urban and rural areas. With rapid technology growth the conventional bridge has been replaced by innovative cost effective structural system. One of these solution present two structural systems that are reinforced concrete T-Girder and Box-Girder Bridge for different span length. T-Girder Bridge Structural constructions are easy to construct not sophisticated as Box-girder Bridge.

The analysis and design of reinforced concrete T-girder and Box-girder bridges using excel spread sheet template takes longer time, demands more effort and requires high degree of accuracy. Moreover, the economical span range for the two types of bridges is not clearly demarcated. As referred to many literatures there is overlap of span range for the two types of bridges.

Economy is the governing factor among other requirements of a bridge like aesthetics, maintainability, for developing countries like Ethiopia. Hence, in view of saving investments also facilitating the design and design checking process, a comparative study to select and identify the economical span range of T- and Box- girder bridges on the basis of cost of materials (construction cost) is the focus of this study.

1.2 Objective of the Project

- To prepare a Excel and Software program for Analysis and Design of the superstructure of T-girder and Box- girder bridges following AASHTO LRFD Bridge Design Specifications with reference to Ethiopian Roads Authority (ERA) Bridge Design Manual, and any other internationally & nationally accepted design standards; and to demarcate the economical span with a better degree of accuracy using cost as basis of comparison.
- To selected with the aid of the developed program, the more appropriate type of bridge used or to be used.

1.3 Content of the Project

Six chapters are contained within this study, where,
Chapter 1:- deals with introducing the general background and objectives of the Project work.
Chapter 2:- is devoted to literature review
Chapter 3:-Loading and Bridge design consideration
Chapter 4:- Numerical analysis and Design
Chapter 5:-Result and discussion
Chapter 6:-Conclusion and recommendation

CHAPTER 2 LITERATURAL REVIEW

2.1 Design standards

2.1.1 ERA Bridge Design manual

ERA Bridge Design Manual deal with small and medium sized structures and used for all structures within the Ethiopian Roads Authority (ERA) throughout the country. This standard is based mainly on the American Association of State Highway and Transportation Officials (AASHTO) LRFD Bridge Design Specifications, 2nd edition, 1998, with modifications to Ethiopian conditions, requirements, and applicable laws of the Federal Democratic Republic of Ethiopia.

The Design Standard provides all the necessary procedural guidance, dimensions, and materials advice to enable a civil engineer with some field experiences to prepare appropriate preliminary and detailed designs for small and medium sized bridges.

The manual covers the entire design process in terms of both the:

- Time-related process, proceeding from feasibility study through preliminary design and final design to bridge inspection and strength evaluation of old bridges; and
- Total design from foundations to superstructure to bearing and railing.

2.1.2 AASHTO LRFD Bridge Design manual

On December 12, 1914, the American Association of State Highway Officials (AASHO) was formed, and in 1921 its Committee on Bridges and Allied Structures was organized. The charge to this committee was the development of standard specifications for the design, materials, and construction of highway bridges. The first edition of the Standard Specifications for Highway Bridges and Incidental Structures was published in 1931 by AASHO, the predecessor to AASHTO.

In the beginning, the design philosophy utilized in the standard specification was working stress design (also known as allowable stress design). In the 1970s, variations in the uncertainties of loads, such as vehicular loads and wind forces, were considered and load factor design was introduced as an alternative method. In 1986, the Subcommittee on Bridge and Structures initiated a study on incorporating the load and resistance factor design (LRFD) philosophy in to the standard specification. This study recommended that LRFD be utilized in the design of highway bridges. The LRFD method is introduced by AASHTO since 1994.

2.2 Bridge Types

Reinforced concrete sections, used in the bridge superstructures, usually consist of slabs, T-beams (deck girders), and box girders. Safety, cost-effectiveness, and aesthetics are generally the controlling factors in the selection of the proper type of bridges. Occasionally, the selection is complicated by other considerations such as the deflection limit, life-cycle cost, traffic maintenance during construction stages, construction scheduling and worker safety, feasibility of false work layout, passage of flood debris, seismicity at the site, suitability for future widening, and commitments made to officials and individuals of the community. In some cases, a prestressed concrete or steel bridge may be a better choice.

Reinforced Concrete is used extensively in highway bridges in short and medium spans because of its economy, durability, low maintenance costs, adaptability to any geometric alignment, and ease of construction. The major advantage in the use of concrete bridge is the wide variation that can be achieved in form.

2.2.1 T-Girder Bridge

The T-Girder bridge construction consists of a transversely reinforced slab deck which spans across to the longitudinal support girders. These require a more-complicated formwork, particularly for skewed bridges, compared to the other superstructure forms. T-Girder bridges are generally more economical for spans of 12 to 20 m. The girder stem thickness usually varies from 35 to 55 cm and is controlled by the required horizontal spacing of the positive moment reinforcement. Optimum lateral spacing of longitudinal girders is typically between 1.8 and 3.0 m for a minimum cost of formwork and structural materials. However, where vertical supports for the formwork are difficult and expensive, girder spacing can be increased accordingly.

2.2.2 Box Girder Bridge

Box-girder bridges contain top deck, vertical web, and bottom slab and are often used for spans of 15 to 36 m with girders spaced at 1.5 times the structure depth. Beyond this range, it is probably more economical to consider a different type of bridge, such as post-tensioned box girder or steel girder superstructure. This is because of the massive increase in volume and materials. They can be viewed as T-beam structures for both positive and negative moments. The high torsional strength of the box girder makes it particularly suitable for sharp curve alignment, skewed piers and abutments, super elevation, and transitions such as interchange ramp structures.

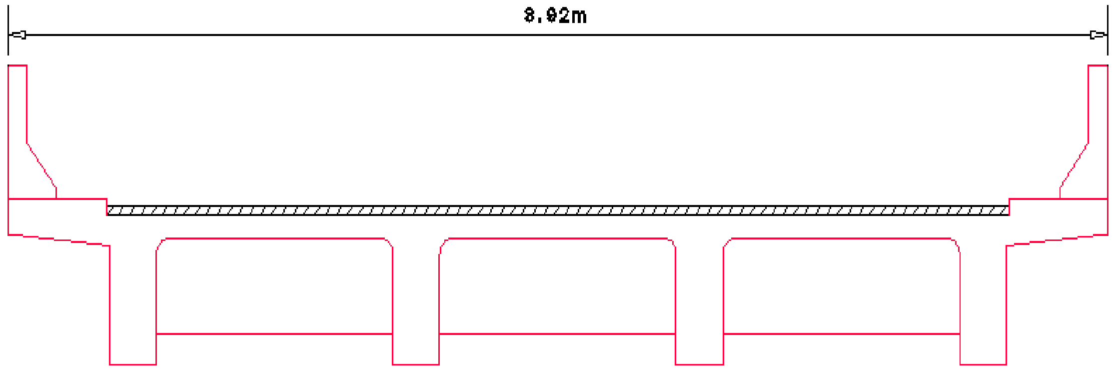


Figure 2-1: T-Girder Bridge

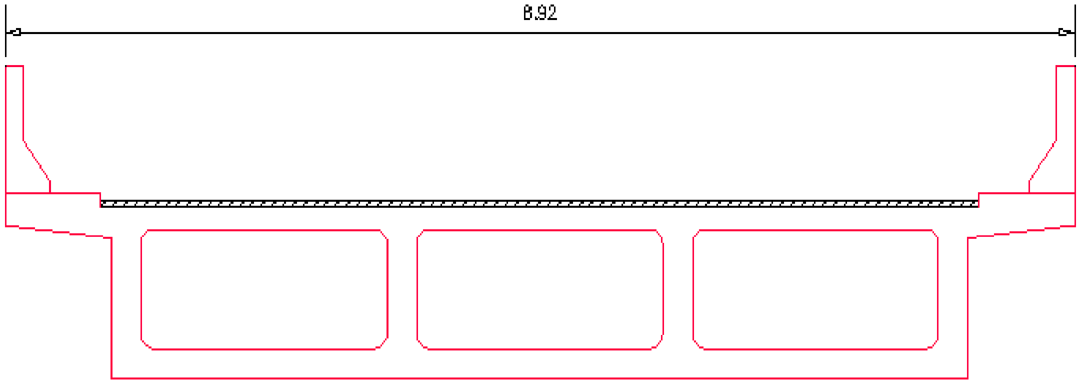


Figure 2-2: Box-Girder Bridge

2.3 Material

The raw materials of concrete, consisting of water, fine aggregate, coarse aggregate, and cement, can be found in most areas of the world and can be mixed to form a variety of structural shapes. The great availability and flexibility of concrete material and reinforcing bars have made the reinforced concrete bridge a very competitive alternative.

2.3.1 Concrete

The compressive strength of concrete (fc) at 28 days after placement is usually obtained from a standard 150-mm-diameter by 300-mm-high cylinder loaded longitudinally to failure. The stress–strain curves from unconfined concrete cylinders under uniaxial compression loading. The strain at the peak compression stress f'c is approximately 0.002 and maximum usable strain is about 0.003.

The concrete modulus of elasticity, Ec, may be calculated as,

$$E_c = 0.043\gamma_c^{1.5}\sqrt{f_c} \quad \text{Mpa} \qquad \text{……………………………………eq.2.1}$$

Where: γ_c = density of concrete (kg/m^3)
f'_c = specified cylinder strength of concrete (MPa)

For normal density concrete with γ_c = 2 400 kg/m^3 , E_c shall be taken as:

$$E_c = 4800\sqrt{f_c} \ \text{Mpa} \qquad \text{…………………………………………..eq.2.2}$$

Poisson's ratio shall be assumed as 0.2. For components which are expected to be subject to cracking, the effect of Poisson's ratio shall be neglected.

The concrete compressive strength or class of concrete should be specified in the contract documents for each bridge component. These classes are intended for use as follows:

- Class A concrete is generally used for all elements of structures and especially for concrete exposed to salt water.
- Class B concrete is used in footings, pedestals, massive pier shafts, and gravity walls.
- Class C concrete is used in thin sections under 100 mm in thickness, such as reinforced railings and for filler in steel grid floors.
- Class P concrete is used when strengths exceeding 28 MPa are required.
- Class S concrete is used for concrete deposited under water in cofferdams to seal out water.

Both concrete compressive strengths and water–cement ratios are specified in for different concrete classes. This is because the water–cement ratio is a dominant factor contributing to both durability and strength, while simply obtaining the required concrete compressive strength to satisfy the design assumptions may not ensure adequate durability.

2.3.2 Reinforcement

Deformed steel bars are commonly employed as reinforcement in most reinforced concrete bridge construction. The surface of a steel bar is rolled with lugs or protrusions called deformations in order to restrict longitudinal movement between the bars and the surrounding concrete. Reinforcing bars, rolled according to ASTM A615/A615M specifications (billet steel), are widely used in construction. ASTM A706/A706M low-alloy steel deformed bars (Grade 420 only) are specified for special applications where extensive welding of reinforcement or controlled ductility for earth-quake-resistant, reinforced concrete structures or both are of importance.

1. Bar Shape and Size

Deformed steel bars are approximately numbered based on the amount of millimeters of the nominal diameter of the bar. The nominal dimensions of a deformed bar are equivalent to those of a plain round bar which has the same mass per meter as the deformed bar.

2. Stress–Strain Curve

The behavior of steel reinforcement is usually characterized by the stress–strain curve under uniaxial tension loading. Typical stress–strain curves for steel Grade 300 and 420 are shown in Figure 2.3. The curves exhibit an initial linear elastic portion with a slope calculated as the modulus of elasticity of steel reinforcement Es = 200,000 MPa; a yield plateau in which the strain increases (from εv to εh) with little or no increase in yield stress (fy); a strain-hardening range in which stress again increases with strain until the maximum stress (fu) at a strain (εu) is reached; and finally a range in which the stress drops off until fracture occurs at a breaking strain of εb.

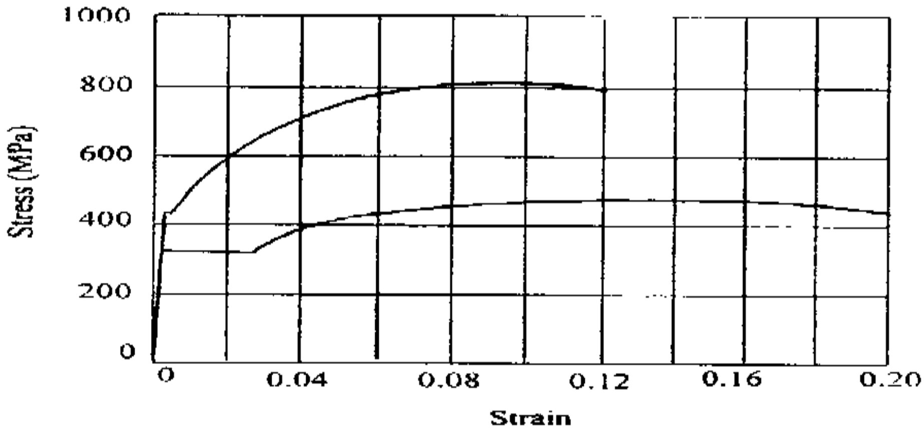


Figure 2-3: Typical strain-stress curve for reinforcement

CHAPTER 3 LOADING AND BRIDGE DESIGN CONSIDRATIONS

3.1 Design Considerations

3.1.1 Loading

Designers must consider all the loads that are expected to be applied to the bridge during its service life. Such loads may be divided in to two broad categories: permanent loads and transient loads.

Permanent loads are those that remain on the bridge for an extended period of time, perhaps for the entire service life. Such loads include:

- Dead load of structural components and non-structural attachments
- Dead load of wearing surfaces and utilities
- Dead load of earth fill
- Earth pressure, earth surcharge and down drag
- Locked-in erection stresses

Transient loads, as the name implies, change with time, highly variable and may be applied from several directions and/ or locations. Typically, such loads include:

- Gravity loads due to vehicular and pedestrian traffic
- Horizontal vehicular loads, such as those due to braking, centrifugal forces
- Lateral loads due to wind, water and earthquake
- Collision loads, caused either by a service vehicle striking the structure, or by some moving object in the channel beneath the bridge
- Load due to thermal effects

The design vehicular live load was replaced in 1993 because of heavier truck configurations on the road today, and because a statically representative, notional load was needed to achieve a “consistent level of safety.” The notional load that was found to best represent “exclusion vehicles,” i.e. trucks with loading configurations greater than allowed but routinely granted permits by agency bridge rating personnel, was adapted by

AASHTO and named “Highway Load ‘93” or HL 93. It is notional in that it does not represent any specific vehicle.The AASHTO “design vehicular live load,” HL 93, is a combination of a “design truck” or “design tandem” and a “design lane”.

Design Truck: is a model load that resembles the typical semitrailer truck. The front axle is 35 KN, the drive axle of 145 KN is located 4.3 m behind, and the rear trailer axle is also 145 KN and is positioned at a variable distance ranging between 4.3 m and 9 m. The variable range means that the spacing used should cause critical load effect.

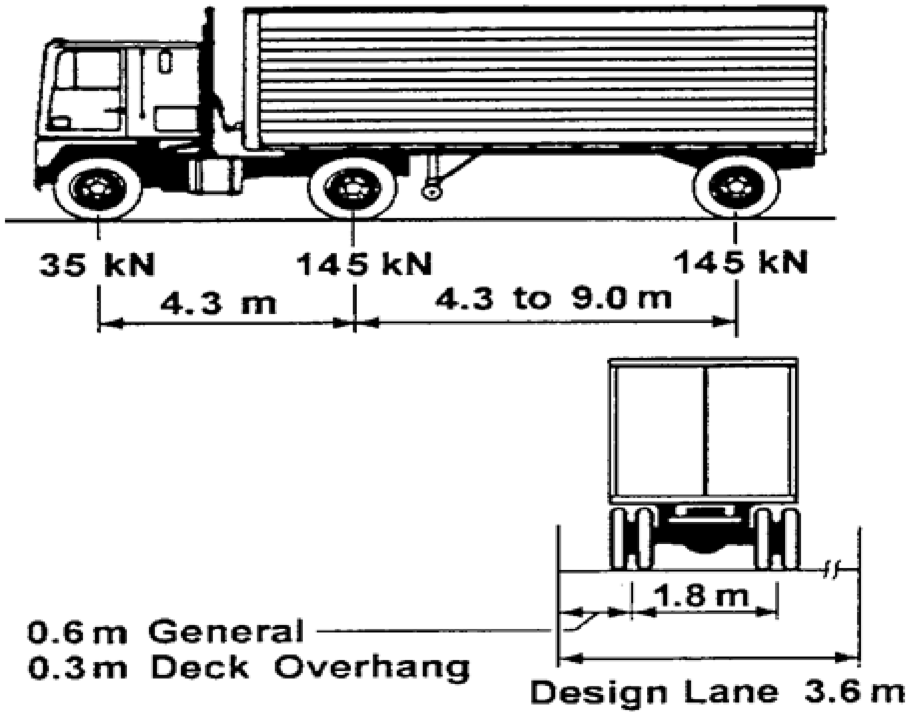


Figure 3-1: Characteristic of Design truck loading

Design Tandem: The design tandem shall consist of a pair of 110 KN axles spaced 1.2 m apart. The transverse spacing of wheels shall be taken as 1.8 m. A dynamic load allowance shall be considered.

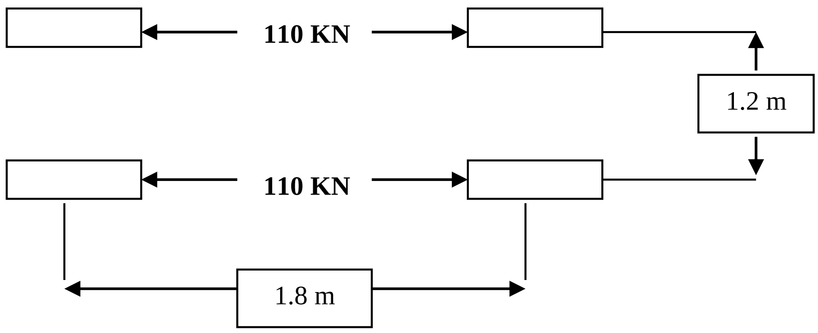


Figure 3-2: Characteristic of Design Tandem loading

Design Lane Load: The design lane load shall consist of a load of 9.3 KN/m uniformly distributed in the longitudinal direction. Transversely, the design lane load shall be assumed to be uniformly distributed over 3.0m width. The force effects from the design lane load shall not be subjected to a dynamic load allowance.

3.2 Design Specification

Bridge Site Arrangement

The choice of location of bridges shall be supported by analyses of alternatives with consideration given to economic, engineering, social, and environmental concerns as well as cost of maintenance and inspection associated with the structures and with the relative of the above-noted concerns. Attention, commensurate with the risk involved, shall be directed towards providing for favorable bridge locations that:

- Fit the conditions created by the obstacle being crossed
- Facilitate practical cost effective design, construction, operation, inspection and maintenance
- Provide for the desire level of traffic service and safety
- Minimize adverse highway impacts

Width of Bridge Deck

The width of the bridge should correspond with the roadway or carriage way width and it is to be measured between the inside of the railings or the curbs. The bridge width shall not be less than that of the approach roadway section, including shoulders or curbs, gutters, and sidewalks.

The inside face of a barrier should not be closer than 600 mm to either the face of the object or the edge of a designated traffic lane. The specified minimum distance between the edge of the traffic lane and fixed object are intended to prevent collision with slightly errant vehicles and those carrying wide loads.

If not otherwise stated in the ERA Geometric Design Manual, 2002, a one-lane bridge shall not be less than 4.2 m wide and a two-lane bridge not less than 7.0 m wide.

Table 3-1: Bridge Width

Application	Width (m)
Two-lane in “urban” area	10.30
Two-lane in “rural” area	7.30
Single Lane	4.20
Pedestrian Overpass	3.0

Number of Design Lanes

The number of design lanes should be determined by taking the integer part of the ratio w/3600, where w is the clear roadway width in mm between curbs and/or barriers.

$$N_L = INT\ ((R_w * 10^3)/3600)$$

Where:
NL is number of design lanes
Rw is roadway width of the bridge (m)

Multiple Presence Factor

Trucks will be present in adjacent lanes on roadway with multiple design lanes, but it is unlikely that three adjacent lanes will be loaded simultaneously with the heavy loads. Therefore, some adjustments in the design loads are necessary. To account for this effect, AASHTO LRFD Bridge Design Specifications, 2005, provides an adjustment factor for the multiple presences.

Table 3-2: Multiple Presence Factors, m

Number of Loaded Lanes	1	2	3	>3
Multiple Presence Factors "m"	1.20	1.00	0.85	0.65

Dynamic Load Allowance

This factor accounts for hammering when riding surface discontinuities exist, and long undulations when settlement or resonant excitation occurs.

Unless otherwise permitted in AASHTO LRFD Bridge Design Specifications, 2005, the static effects of the design truck or tandem, other than centrifugal and braking forces, shall be increased by the percentage specified in Table 4.3 for dynamic load allowance.
The factor to be applied to the static load shall be taken as (1+IM/100). The dynamic load allowance shall not be applied to pedestrian loads or to the design lane load.

Table 3-3: Dynamic Load Allowance, IM

Component	IM
Deck Joints-All Limit States	75%
All Other Components	
• Fatigue and Fracture Limit States	15%
• All other Limit States	33%

Dynamic load allowance need not be applied to:

- ✓ Retaining walls not subject to vertical reactions from the superstructure, and
- ✓ Foundation components that are entirely below ground level.

The dynamic load allowance shall be reduced for components, other than joints, if justified by sufficient evidence, but in no case shall the dynamic load allowance used in design be less than 50% of IM in the table above.

Load factors and Load combination

Consider the investigation of uplift. Where a permanent load produces uplift, that load would be multiplied by the maximum load factor, regardless of the span in which it is located. If another permanent load reduces the uplift, it would be multiplied by the minimum load factor, regardless of the span in which it is located. For example, at Strength I Limit State where the permanent load reaction is positive and live load can cause a negative reaction, the load combination would be:

$$0.9DC + 0.65DW + 1.75(LL+IM)$$

If both reactions were negative, the load combination would be:

$$1.25DC + 1.50DW + 1.75(LL+IM).$$

3.2.1 Design Assumptions

The following assumptions are made in

- ✓ Abutments are assumed to be the same for both T-Girder and Box Girder bridges of the same span length. Hence, design of abutments and its associated cost are not taken in to account for cost comparisons,
- ✓ Although the dead loads of railings, curbs and posts are considered during the analysis, design and in quantity computations, it is assumed that the loads are the same for the same span of both T- Girder and Box Girder bridges,
- ✓ The cost of elastomeric bearing for both T-Girder and Box Girder bridges is the same

3.3 Design Limit State

Structural components shall be proportioned to satisfy the requirements at all appropriate service, fatigue, strength and extreme event states. Prestressed and partially prestressed concrete structural components shall be investigated for stresses and deformations for each stage that shall be critical during construction, stressing, handling, transportation, and erection, as well as during the service life of the structure of which they are part. Stress concentrations due to prestressing or other loads, and restraints or imposed deformations shall be considered.

3.3.1 Service Limit State (SLS)

For concrete structures, service limit states correspond to the restrictions on cracking width and deformations under service conditions. They are intended to ensure that the bridge will behave and perform acceptably during its service life.

1 Control of Cracking

Cracking may occur in the tension zone for reinforced concrete members due to the low tensile strength of concrete. Such cracks may occur perpendicular to the axis of the members under axial tension or flexural bending loading without significant shear force, or inclined to the axis of the members with significant shear force. The cracks can be controlled by distributing steel reinforcements over the maximum tension zone in order to limit the maximum allowable crack widths at the surface of the concrete for given types of environment. The tensile stress in the steel reinforcement (*fs*) at the service limit state should not exceed

$$f_{sa} = \frac{Z}{(d_c A)^{1/3}} \leq 0.6 f_y \quad \text{…………………} \text{ eqn.3.1}$$

Where:

d_c = depth of concrete measured from extreme tension fiber to center of bar or wire located closest thereto; for calculation purposes, the thickness of clear cover used to compute d_c shall not be taken to be greater than 50 mm

A = area of concrete having the same centroid as the principal tensile reinforcement and bounded by the surfaces of the cross-section and a straight line parallel to the neutral axis, divided by the number of bars or wires (mm^2); for calculation purposes, the thickness of clear concrete cover used to compute A shall not be taken to be greater than 50 mm

Z = crack width parameter (N/mm)

Except for cast-in-place reinforced concrete box culverts, the quantity Z in Equation 3.1 shall not exceed 30 KN/mm for members in moderate exposure conditions, 23 KN/mm for members in severe exposure conditions, and 17.5 KN/mm for buried structures. Several smaller tension bars at moderate spacing can provide more effective crack control by increasing *fsa* rather than installing a few larger bars of equivalent area.

When flanges of reinforced concrete T-beams and box girders are in tension, the flexural tension reinforcement should be distributed over the lesser of the effective flange width or a width equal to $1/10$ of the span in order to avoid the wide spacing of the bars. If the effective flange width exceeds $1/10$ of the span length, additional longitudinal reinforcement, with an area not less than 0.4% of the excess slab area, should be provided in the outer portions of the flange.

For flexural members with web depth exceeding 900 mm, longitudinal skin reinforcements should be uniformly distributed along both side faces for a height of *d*/2 nearest the flexural tension reinforcement for controlling cracking in the web. Without such auxiliary steel, the width of the cracks in the web may greatly exceed the crack widths at the level of the flexural tension reinforcement. The area of skin reinforcement (A_{sk}) in mm^2/mm of height on each side face should satisfy

$$A_{sk} \geq 0.001(d_e - 760) <= A/1200 \text{……………………………eqn.3.2}$$

Where d_e (mm) is the flexural depth from extreme compression fiber to the centroid of the tensile reinforcement and A_s (mm^2) is the area of tensile reinforcement and prestressing steel. The maximum spacing of the skin reinforcement shall not exceed *d*/6 or 300 mm.

2. Control of Deformations

Service-load deformations in bridge elements need to be limited to avoid the structural behavior which differs from the assumed design conditions and to ease the psychological effects on motorists. Service-load deformations may not be a potential source of collapse mechanisms but usually cause some undesirable effects, such as the deterioration of wearing surfaces and local cracking in concrete slab which could impair serviceability and durability. AASHTO LRFD provides two alternative criteria for controlling the deflections:

Limiting Computed Deflections (AASHTO 2.5.2.6.2):

Vehicular load, general	Span length/800
Vehicular and/or pedestrian loads	Span length/1000
Vehicular load on cantilever arms	Span length/300
Vehicular and/or pedestrian loads on cantilever arms	Span length/1000

Deflections of bridges can be estimated in two steps:

(1) Instantaneous deflections which occur at the first loading and

(2) Long-time deflections which occur with time due to the creep and shrinkage of the concrete.

Table 3-4: Minimum depth for constant depth Superstructures

Bridge types	Minimum depth (including deck)	
	Simple span	Continuous span
Slab bridge	1.2(S+3000)/30	(S+3000)/30 ≥ 165mm
T-girder bridge	0.070L	0.065L
Box girder bridge	0.060L	0.055L

Where:

S = Span length for slab bridge

L = Span length for girder bridge

3.3.2 Fatigue Limit State

Fatigue limit states are used to limit stress in steel reinforcements to control concrete crack growth under repetitive truck loading in order to prevent early fracture failure before the design service life of a bridge. Fatigue loading consists of one design truck with a constant spacing of 9000 mm between the 145-KN axles. Fatigue is considered at regions where compressive stress due to permanent loads is less than two times the maximum tensile live-load stress resulting from the fatigue-load combination. Allowable fatigue stress range in straight reinforcement is limited to

$$f_f = 145 - 0.33 f_{min} + 55\ (r/h) \quad\text{.......... } 3.3$$

where f_{min} (MPa) is the minimum stress in reinforcement from fatigue loading (positive for tension and negative for compression stress) and r/h is the ratio of the base radius to the height of rolled- on transverse deformations (0.3 may be used if the actual value in not known).

The cracked section properties should be used for fatigue. Gross section properties may be used when the sum of stresses, due to unfactored permanent loads, plus 1.5 times the fatigue load.

3.3.3 Strength Limit State

For reinforced concrete structures, strength and extreme event limit states are used to ensure that strength and stability are provided to resist specified statistically significant load combinations.

CHAPTER 4 NUMERICAL ANALYSIS AND DESIGN

4.1 T-Girder Bridge

4.1.1 Traversal direction design

1. Design Data		
Design parameters		
Number of Spans =	1	
Skew Angle=	0	degree
Crown Slope in %=	2	%
Bridge Clear Span Lc =	14	m
Side walk =	0.8	m
Clear Roadway width w =	7.32	m
Total Roadway width w =	8.92	m
Number Of Lanes =	2	
Multiple presence Factor=	1	
Rear Axle Load =	145	KN
P =	72.5	KN
Lane Load in the Transverse Direction=	9.30	KN/m^2
	3.10	KN/m
Design Tandum Axle Load=	110.00	KN
	55.00	KN
Wearing Surface =	1.1	KN/m^2
Highway Railing Load, P_h=	44.5	KN
1.2 Material Data		
Concrete		
Type of concrete: C-30 concrete cube	24	Mpa
Unit weight of Concrete, g_c =	24	KN/m^3
Concrete Modulus of Elasticity Ec =	24.768	Gpa
Reinforcement		
For bar dia >=20 fyk = 60918.88 Psi	420	Mpa
For bar dia <20 fyk = 43513.49 Psi	300	Mpa
Steel Modulus of Elasticity Es =	200	Gpa
Modular ratio, n =Es/Ec=	8	
1.3 Load and Resistance Factors:		
f momen t=φ =	0.9	
f shear =φ =	0.9	
b=	0.85	
Dead Load limit state factor =	1.25	
Live Load Limit state facctor =	1.75	
Dead Load Service Limit State factor=	1	
Live load service limit state factor =	1.3	
Fatigue Live Load Factor =	0.75	

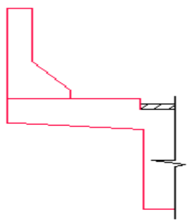
	Dyanmic impact allowance				
	Fatigue and Fracture	15	%		
	All other Limit state	33	%		
	Modulus of rupture=fr=0.63sqrt(fc') =	3.086357076	MPa	Eq.9.50	
	Z in Eq. 9.5 =	30000	KPa		
2. Determination of Section for Superstructure					
			Effective Span L =	14.00	m
			Girder Depth D = 0.07(L) =	0.98	m
			Take D =	1	**m**
			Number of Girders =	4	
			C/C girder spacing =	2.3	**m**
			End of slab to center of exterior girder=	1.010	m
			Web width =	0.38	m
			Clear b/n girders	1.92	mm
			No. of bars in one layer =	4	
			fillet	0.1	m
			Slab thickness (a/12 to a/15)Df =	0.18	m
			Take Top Slab thickness Df =	0.2	m
			Take Overhang Slab thickness =	0.23	m
			Clear span of overhang =	0.82	m
			Edge Beam Width =	0.4	m
			Edge Beam Depth =	0.4	m
			Diaphragm ,use at centre and Ends. Thickness=	0.25	m
			Depth of Diap @ cente =	0.90	m
			Depth of Diap@ end =	0.90	m
			Number of Intermidiate Diaphragm	1	
			Number of End Diaphragm	2	
			C/C distance b/n Diaphragm =	7.00	m

3.0 Deck Slab Design

3.1 Design of the Overhanging Slab

3.1.1 Dead Loads and Moments

Item	Weight (KN/m	Moment arm(m)	Moment (KNm/m)
Barrier Load	3.957	0.63	2.493
Over hang slab load	6.125	0.41	2.511
Wearing surface(DW	**0.231**	0.715	**0.165**
Total (DC)	**10.082**		**5.004**



Over hang part

3.1.2Live Load on Overhang Slab

According to Art `2.9 and eq 7.14, Wheel loads are applied on an effective length of E =1140+ 0.833X

X - Distance in mm from center of post to point under investigation

Railing Load

X=	0.73	m
E = 1140+ 0.833X =	1748.09	mm
E=	1.75	m
Prail	44.50	KN
M_LL =P/E =	25.46	KN/m
M_LL =P(X/E) =	18.583	KNm/m

According to Art 3.24.5.1 & 3.24.5.2, Wheel loads are applied on an effective length of E =1140+ 0.833X

X - Distance in mm from load to point of support

Truck Load

X =	0.720	m
E = 1140+ 0.833X =	1739.760	mm
E =	1.74	m
M_LL =P/E =	41.67	KN/m
M_LL =P(X/E) =	30.004	KNm/m
M-LL IM=	39.906	KNm/m
lane=	1.042	KNm/m
M-LL tot	40.948	KNm/m

3.1.3 Total moment

$Q = \Sigma \eta_i$ ' Here, $\eta_D = \eta_R = 1.($ $\eta_I = 1.00$ Design momer = 1.00(1.25 DC + 1.5 DW + 1.75 LL+IM)

a) Dead load plus rail live load

$M_{TR} = 1.25M_{DL+}1.5MDW+1.75M_{RLL}$

= 39.023339 kNm/m

b) Dead load plus truck live load

$M_{TT} = 1.25M_{DL+1.5*MDW}+1.75M_{LL}$

= 78.161362 kNm/m

c) Design moment

$M_D = \max(M_{TR}, M_{TT})$

= <u>**78.16**</u> kNm/m

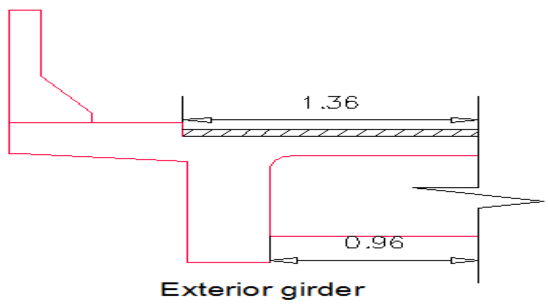
alanced Steel Ratio=	$\rho_b = \alpha \dfrac{0.003}{\dfrac{fy}{E_S} + 0.003} \dfrac{fc}{fy}$	0.0384		
	Using only r= 0.75r$_b$ =	0.0288		
Depth Required, dre	$d_{req} = \sqrt{\dfrac{Mu}{\phi\rho\ fy\ b\left(1 - 0.59\rho \dfrac{fy}{fc}\right)}} =$	112.97	mm	
	Cover =	25	mm	
Use Rebars of diameter =		16	mm	
	davailable =	197.00	mm	OK
Area of Reinforcement Required As =	$A_S = \dfrac{M_U}{\Phi f_y (d - (a/2))}$			
	Assume a =	22.94	mm	
	As =	1560.32	mm²	
	Check a :			
	$a = \dfrac{A_S f_y}{0.85 f_C' b}$ a =	22.95	mm	OK
	As_req =	1560.32	mm²	
	Area of One bar , a_s =	201.06	mm²	
Spacing, S =	$S = \dfrac{1000 a_S}{A_S}$	128.86	mm	
	Use diameter 16	mm c/c	120	mm Top
	As_actual =	1675.52	mm²	
3.2 Design of interior Slab				
	C/C of Supports (Girders) =	2.30	m	
Loads on the Slab				
3.2.1 Dead Load				
	Slab = g_C*Df =	4.80	KN/m²	
	Side Walk	0	KN/m²	
	Wearing Surface =	1.10	KN/m²	
	Total =	4.80	KN/m²	
	Total w_DL =	4.80	KN/m²	
	Continuity Factor K =	0.8	Continuous Supports	
	M_DL =k*wS²/8 =	2.54	KNm/m	
	M_DW =k*wS²/8 =	0.58	KNm/m	
3.2.2 Live Load				
	P_20 =	72.50	KN =	
		55.00	KN =	
	Continuity Coefficient, K =	0.80	Continuous Supports	
	Et = 660+ 0.55S =	1925.00	mm	
	Et =	1.93	m	

M_LLt =K*P(S/4E) =	17.32	KNm/m	
Eb = 1220+ 0.25S =	1795.00	mm	
Eb =	1.80	m	
M_LLb =K*P(S/4E) =	18.58	KNm/m	
M Lane=	1.64	KNm/m	
M_LLt=	17.32	KNm/m	
M_LLb=	18.58	KNm/m	
M_LLt + I =	23.04	KNm/m	
M_LLb + I =	24.71		
25 M_DL +1.5MDW+1.75*(M_LLt+I+M_Lane) =	47.24	KNm/m	
	50.16		
alanced Steel Ratio= $\rho_b = \alpha \frac{0.003}{\frac{fy}{E_s}+0.003}\frac{fc}{fy}$	0.0384		
Using only r= 0.75r$_b$ =	0.0288		
Depth Required, dre $d_{req} = \sqrt{\frac{Mu}{\phi\rho\ fy\ b\left(1-0.59\rho\frac{fy}{fc}\right)}} =$	90.50	mm	
Top Main Reinforcement			
Cover =	25.00	mm	
Use Rebars of diameter =	16	mm	
davailable =	167.00	mm	OK
Area of Reinforcement Required As = $A_S = \frac{M_U}{\Phi f_y(d-(a/2))}$			
Assume a =	16.19	mm	
As =	1100.98	mm²	
Check a :			
$a = \frac{A_S f_y}{0.85 f_c' b}$ a =	16.19	mm	OK
As_req =	1100.98	mm²	
Area of One bar , a$_s$ =	201.06	mm²	
Spacing, S = $S = \frac{1000a_S}{A_S}$	182.62	mm	
Use diameter 16	mm c/c	180	mm Top
As_actual =	1117.01	mm²	
Bottom Main Reinforcement			
Use Rebars of diameter =	16	mm	
Assume a =	17.25	mm	
As =	1173.01	mm²	
Check a :			
$a = \frac{A_S f_y}{0.85 f_c' b}$ a =	17.25	mm	OK
As_req =	1173.01	mm²	

Area of One bar , as =					201.06193	mm²	
Spacing, S =		$S = \dfrac{1000a_s}{A_s}$			171.41	mm	
		Use diam		16	mm c/c		170 mm Bottom
				As_actual =	1182.72	mm²	
Distribution Steel, As_dist =		$A_{s\_dist} = \dfrac{220}{\sqrt{S}} \leq 67\%$			792.42	mm²	
		Use Rebars of diameter =			12	mm	
		Area of One bar , a_s =			113.10	mm²	
	Spacing of Diameter			12	bar is		142.72 mm
		Use diameter		12	bars c/c		140 mm
Temperature and Shrinkage Reinforcement							
	As per AASHTO Art. 8-20,						
	Provide (1/8)inch²/ft for temperature and shrinkage reinforcement						
				As_temp =	0.125	in²/ft	
				As_temp =	264.58	mm²/m	
Use diameter			12	mm bars			
				a_s =	113.10	mm²	
	Spacing of Diameter			12	bar is		350 mm
		Use Diameter		12	bars c/c		350 mm Top

4.1.2 Longitudinal direction design

4.0. Design of Exterior Girder



4.1 Dead load

4.1.1 Dead load of girder

Item	Weight[KN/m]
overhang	10.082
Top slab	4.608
girder	7.296
wearing surface(DW)	1.496
Total DC	21.986

4.1.2 Dead load of diaphragm

Diaphragm load =	4.03	KN

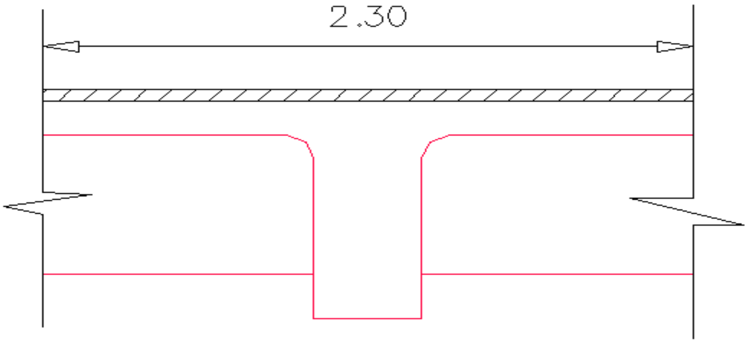
4.1.3 Live load

Live load distribution on a girder

Truck	108.2	KN	
Tandum	82	KN	
Truck loads are therefore			
Front Axel	52	KN	
Middle and Rare Wheel Loads	108.2	KN	
Lane load for Exterior Girder	5.52	KN/m	
*** Point of maximum live load moment =(L/2-.711)/L =**		**6.29**	m at right side

4.1 Interior Girder

4.1.1 Dead load



Interior girder

Dead load of interior girder

Item	Weight[KN/m]
Top slab	11.040
Interior girder	8.208
wearing surface(DW)	2.530
Total DC	19.248

4.1.2 Dead load of diaphragm

Diaphragm load = 8.06 KN

4.1.3 Live load

live load distribution on a girder

Truck	97.6	KN
Tandum	74	KN
Truck loads are therefore		
Front Axel	47	KN
Middle and Rare Wheel Loads	97.6	KN
Lane load for Interior Girder	7.13	KN/m
*** Point of maximum live load moment =(L/2-.711)/L =**	**6.29**	m at right side

4.1.3 Analysis output from sap software

Exterior girder

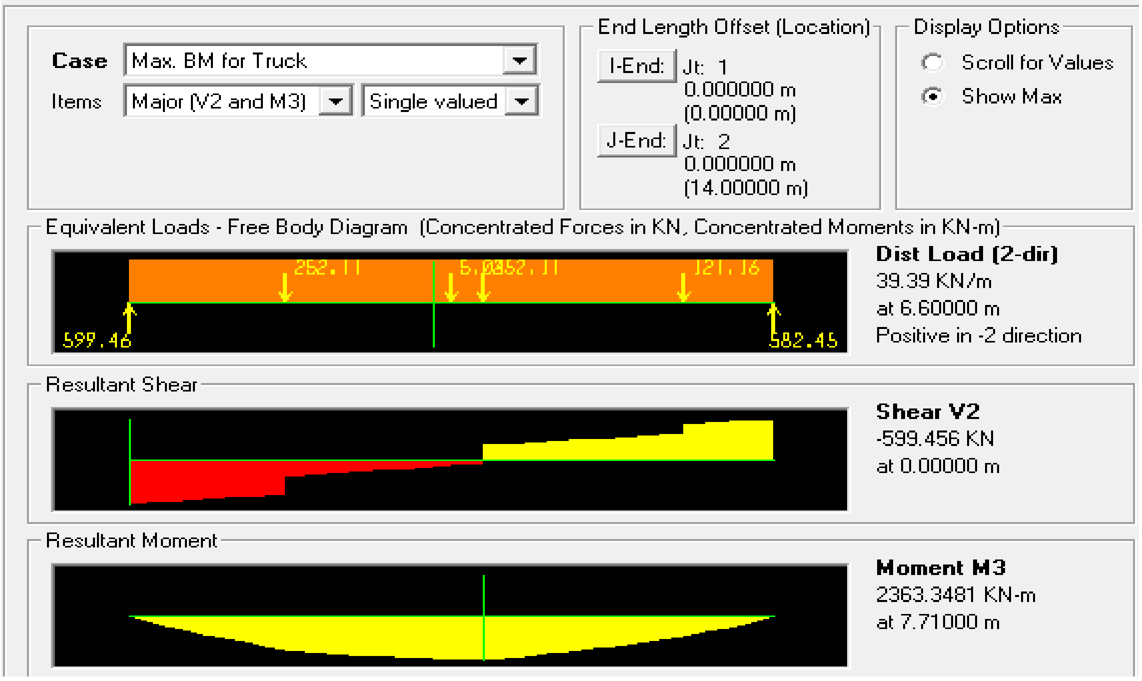
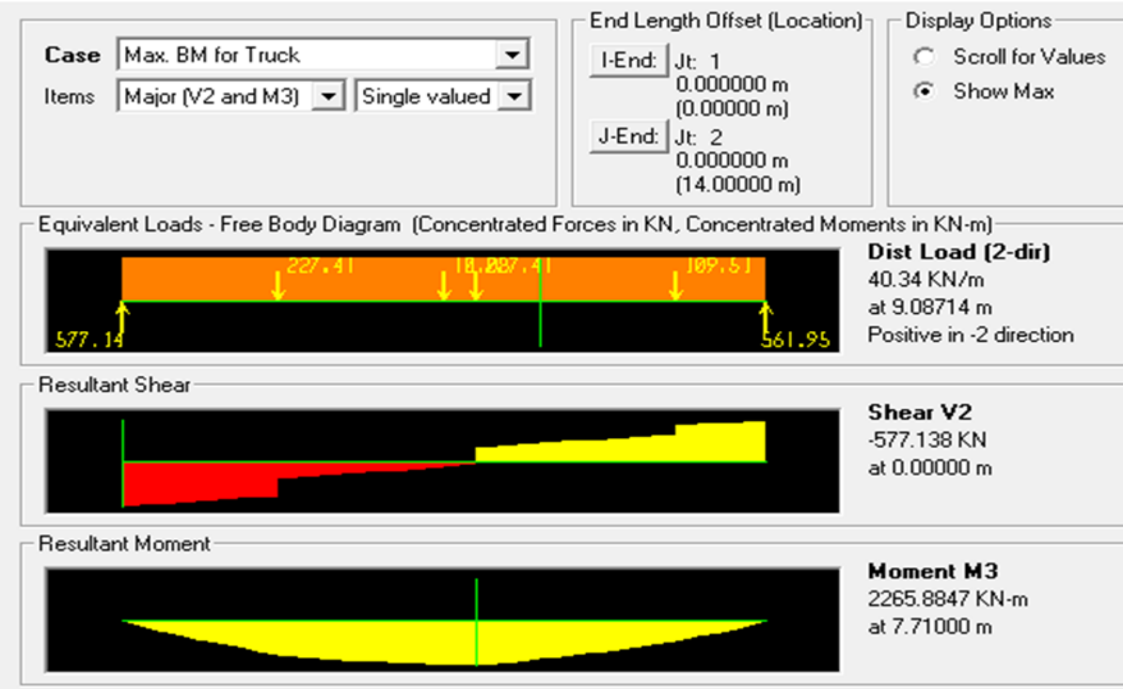


Figure 4-1 Bending Moment and shear force diagram for exterior girder

Interior girder



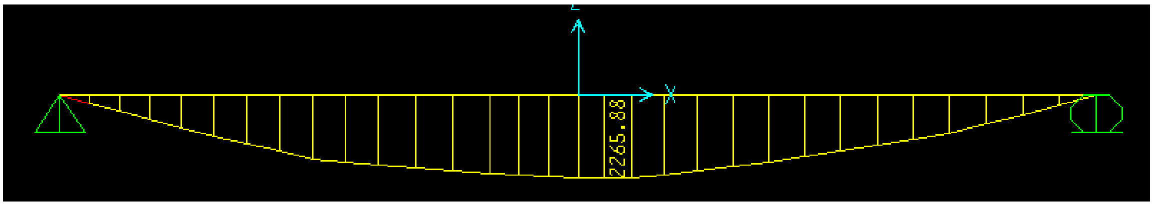


Figure 4-2 Bending Moment and shear force diagram for exterior girder

T-Girder bridge Serviceability Requirement

T-Girder bridge Serviceability Requirements for clear span 14m

Serviceability Requirements

Fatigue Stress Limits

ff = 144.79-0.33fmin+55.12(r/h)			*(Art.5.5.3.2-1)*			
r/h =	0.3					
Mse,max=	2265.88	KNm				
Mse,min =	1733.5296	KNm				
	fs =M/(As*j*d)					
d =	858.00	mm				
As =	9650.97	mm^2				
r =	0.00489053					
$k = \sqrt{2\rho n + (\rho n)^2} - \rho n$		=	0.2433			
j = 1-k/3 =		0.92				
fsmax =	297.79	Mpa				
fsmin =	227.83	Mpa				
f f =	86.14	Mpa				
fsmax - fsm	69.96	Mpa	OK			
Crack Control						
$Z = fs(d_C A)^{1/3}$						
Z =	170	moderate exposure				
Z =	130	r severe exposure				
fs = 0.6 fyk =		36.55	Ksi			
dc =		78	mm =	3.07	inches	
A = 2*Ŷ*bw/No.of Bars =		7291.67	mm^2	11.30	in^2	
Z =		119.23	OK			

Deflection

a =	2.30	m	
Df =	0.18		
L Diaphragm =	1.03		
bw =	0.25		
X =	0.10		
Y=	0.10		
Z =	0.10		
D =	0.90		

First Moment of Area

Item	Area (m^2)	Centroid (m)	Area* Centroid (m^3)
1	0.0200	0.0500	0.0010
2	0.0100	0.1333	0.0013
3	0.2250	0.4500	0.1013
4	0.3690	0.8100	0.2989
Total	0.6240		0.4025
	Ŷ =	**0.6450**	m

Gross Moment of Inertia

Item	Area (m^2)	Yi (m)	Icg(m^4)	d = Ŷ - Yi (m)	Ad^2(m^4)	I_tot (m^4)
1	0.0200	0.0500	0.00002	0.5950	0.0071	0.00710
2	0.0100	0.1333	0.00001	0.5117	0.0026	0.00262
3	0.2250	0.4500	0.01519	0.1950	0.0086	0.02374
4	0.3690	0.8100	0.00100	-0.1650	0.0100	0.01104

Gross moment of Inertia Ig =	0.04451	m^4
Ig =	4.45E+10	mm^4

Cracked Section Moment of Inertia

$$k = \frac{n\rho + \frac{1}{2}\left(\frac{D\_f}{d}\right)^2}{n\rho + \left(\frac{D\_f}{d}\right)}$$

n =	8.00	
r =	0.004891	
d =	858.00	mm
k =	0.2456	
kd =	210.71	mm

Item	Area (m^2)	Yi (m)	Icg(m^4)	d = kd - Yi (m)	Ad^2(m^4)	I_tot (m^4)
Flange	0.41400	0.09000	0.00112	0.12071	0.00603	0.00715
Web	0.00768	0.19536	0.0000006036	0.01536	0.00000	0.00000
Steel	0.07721	0.85800	0.00000	-0.64729	0.03235	0.03235

Icr =	0.03950	m^4
Icr =	3.95E+10	mm^4

$$M_{Cr} = f_r \frac{I_g}{y_t}$$ ***(Art.5.7.3.6.2-2)***

$$f_r = 0.62\sqrt{f_c'}$$ ***(Art.5.7.3.6.2-1)***

f_r =	3.04	N/mm²		
Mcr =	530102007.8	Nmm =	530.10	KNm
Mmax =	2265.88	KNm		

$$I_e = \left(\frac{M_{cr}}{Ma}\right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{Ma}\right)^3\right] I_{cr} \leq Ig$$

Ie = 3.96E+10 mm^4

Ie<Ig, Section Provided is adequate

Dead Load Deflection

$$\Delta_s = \frac{5WL^4}{384EI} + \frac{PL^3}{48EI}$$

W =	64.62	KN/m =	64617.14	N/m
P =	9.84	KN =	9840.00	N
L =	14.00	m		
E =	24.77	Gpa	2.48E+10	N/m²
I = Ie =	3.96E+10	mm^4	0.0395655	m^4
Ds =	0.03355	m =	33.55	mm

Live load

Lane Load

$q_{sup} = wL^3/24EI$

	W (KN/m)	E (Mpa)	I (m4)	q_{sup} (rad)
Exterior girder	6.68	24770	0.04451	**0.00201995**
Interior girder	7.13	24770	0.04451	**0.00215587**

Truck Load

t=Pab(a+2b)/(6EIL)

		a	b	a+2b	ab	EI	p	t	t Total
Exterior girder	irst loa	6.29	6.29	18.87	39.5641	1.10E+03	45.20	4.25E-01	**0.00474**
	2nd	3.41	12.01	27.43	40.9541	1.10E+03	180.78	2.56E+00	
	3rd	12.01	3.41	18.83	40.9541	1.10E+03	180.78	1.76E+00	
interior girder	irst loa	6.29	6.29	18.87	39.5641	3.97E+03	52.07	1.36E-01	**0.00152**
	2nd	3.41	12.01	27.43	40.9541	3.97E+03	208.27	8.19E-01	
	3rd	12.01	3.41	18.83	40.9541	3.97E+03	208.27	5.62E-01	

Rotations Due to Dead & Live Loads

	Dead Load Rot.	Lane Rot	Truck Rot	Total Rot	
Exterior	0.01856	0.00202	0.00474	0.025319294	OK
Interior girder	0.01954	0.0021559	0.00152	0.023211876	OK

4.1.4 Design for flexural in Exterior and Interior girder

Reinforcement detail in the girder

Table 4-1: Flexural Reinforcement detail

x (m)	Exterior Girder			Interior Girder		
	MD	As	No. of bars	MD	As	No. of bars
2.8	1523.15	4825.486	6Φ32	1456.94	4825.486	6Φ32
4.2	1970.43	6433.982	8Φ32	1887.87	6433.982	8Φ32
5.6	2185.98	8042.477	10Φ32	2100.28	7238.229	9Φ32

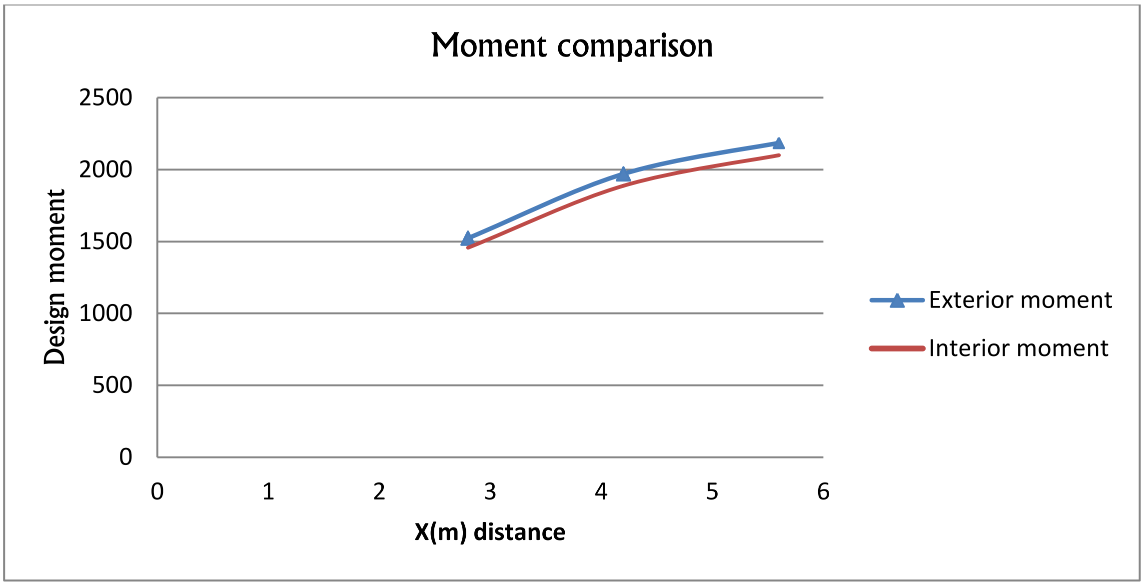


Figure 4-3: Comparative Design moment of exterior and interior girders

Shear reinforcement detail

Table 4-2: Shear Reinforcement detail

14m span length T-girger bridge									
Exterior girder shear Reinforcement									
x(m)	Vu	Mu	Assumed θ	e	θ	β	Vs	S	Spacing of bars
1.25	450.4	593.43	36	0.00043	38	1.9	752.37	193.02	Φ 12 c/c 190 mm
1.4	444.5	659.98	37	0.00048	38	1.6	633.46	195.59	Φ 12 c/c 190 mm
2.8	389.4	1243.76	37	0.0009	39	1.55	567.82	215.43	Φ 12 c/c 200 mm
4.2	334.2	1750.5	38	0.00127	39	1.55	506.54	250.98	Φ 12 c/c 250 mm
5.6	26.97	1851.57	38	0.00134	39	1.55	165.16	3110.19	Φ 12 c/c 300 mm
7	28.18	1851.907	38	0.00134	39	1.55	103.88	2976.54	Φ 12 c/c 300 mm
Interior girder shear Reinforcement									
x(m)	Vu	Mu	Assumed θ	e	θ	β	Vs	S	Spacing of bars
1.25	436.8	577.07	36	0.00042	38	1.9	653.32	201.84	Φ 12 c/c 200 mm
1.4	430.7	641.55	37	0.00046	38	1.6	620.07	204.68	Φ 12 c/c 200 mm
2.8	374.3	1205.07	37	0.00087	39	1.55	552.91	227.27	Φ 12 c/c 220 mm
4.2	317.8	1689.72	37	0.00122	39	1.65	499.01	267.65	Φ 12 c/c 260 mm
5.6	33.9	1798.93	37	0.0013	41	1.65	183.59	2337.26	Φ 12 c/c 300 mm
7	22.57	1808.07	37	0.00131	41	1.65	120.85	3510.55	Φ 12 c/c 300 mm

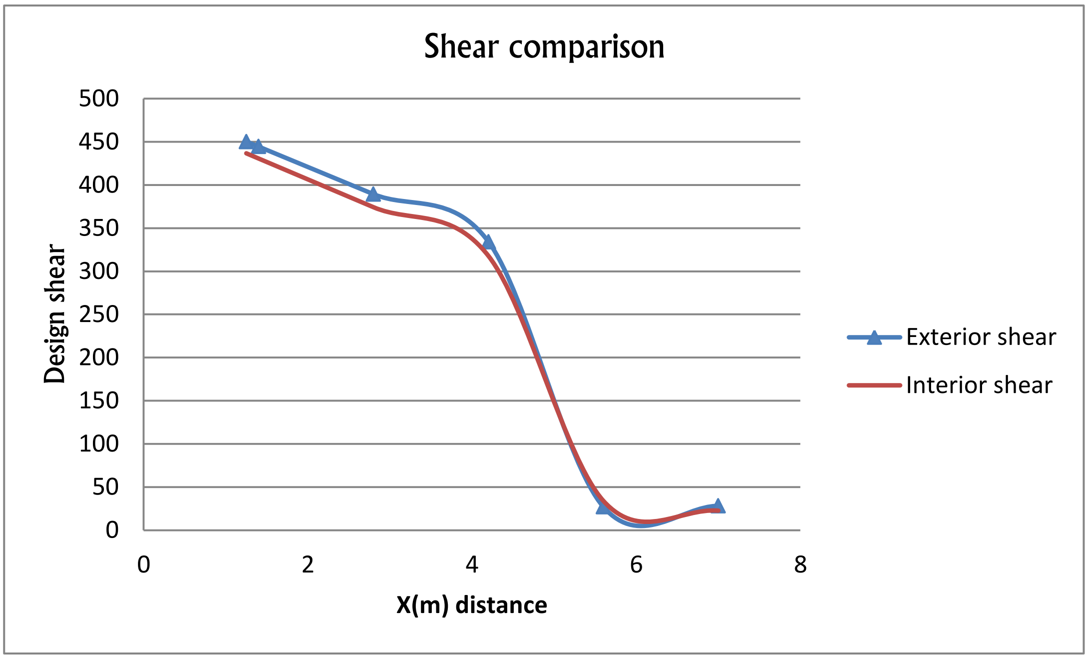


Figure 4-4: Comparative Design shear of exterior and interior girders

4.2 Box Girder Bridge

4.2.1 Traversal direction design

1. Design Data		
Design parameters		
Number of Spans =	1	
Number of Piers =	0	
Skew Angle=	0	degree
Crown Slope in %=	2	%
Bridge Clear Span Lc =	14.0	m
Side walk =	0.80	m
Clear Roadway width w =	7.32	m
Total Roadway width w =	8.92	m
Number Of Lanes =	2	
Multiple presence Factor=	1	
Loading Specification: AASHTO HS20 - 44		
Design Standard	ERA 2002	
Rear Axle Load =	145	KN
P =	72.5	KN
Lane Load in the Transverse Direction=	9.30	KN/m^2
	3.10	KN/m
Design Tandum Axle Load=	110.00	KN
	55.00	KN
Wearing Surface =	1.10	KN/m^2
Highway Railing Load, P_h=	44.5	KN
1.2 Material Data		
Concrete		
Type of conc C-30 concrete cube	24.00	Mpa
Unit weight of Concrete, g_c =	24.00	KN/m³
Concrete Modulus of Elasticity Ec =	24.77	Gpa
Reinforcement		
For bar dia >=20 fyk = 60918.88 Psi	420.00	Mpa
For bar dia <20 fyk = 43513.49 Psi	300.00	Mpa
Steel Modulus of Elasticity Es =	200.00	Gpa
Modular ratio, n =Es/Ec=	8	
1.3 Load and Resistance Factors:		
f momen t=φ =	0.9	
f shear =φ =	0.9	
b=	0.85	
Dead Load limit	1.25	
Live Load Limit	1.75	
Dead Load	1	
Live load	1.3	
Fatigue Live	0.75	

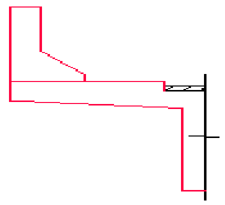
	Dyanmic impact allowance					
	Fatigue abd Frac	15	%			
	All other Limit st	33	%			
	Modulus of ruptu	3.1	MPa	Eq.9.50		
	Z in Eq	30000	KPa			
	For bar Diam>=20mm					
r_b=	0.85b1fc'/fy*(59	0.0243				
	For bar Diam<20mm					
r_b=	0.85b1fc'/fy*(59	0.0385		0.0289		
2.	**Determination of Section for Superstructure**					
	Effective Span L =			14.00	m	
	Girder Depth D = 0.06(L) =			0.84	m	*(Table 2.5.2.6.3.1)*
	Take D =			0.90	**m**	
	Number of Girders =			4	Numbers of girders, Ng =INT(Rw/Gs)+1	
	C/C girder spacing =			2.30	**m**	
	End of slab to center of exterior girder=			1.005	m	
	Web width =			0.25	m	(Art.5.14.1.5.1c and)
	Clear b/n girders			2.05	mm	(C5.1.14.1.5.1c)
	No. of bars in one layer =			4		
	fillet			0.10	m	
	Top Flange=max(175,1/20 Clear fillet Spacing)			0.175	m	*(Article.5.14.1.5.1a)*
	Take Top Flange thickness Df =			0.18	m	
	Bottom Flange=max(140,1/16 Clear Web Spacing)			0.140	m	*(Article.5.14.1.5.1b)*
	Take Bottom Flange thickness Df =			0.15	m	
	Take Overhang Slab thickness =			0.23	m	
	Clear span of overhang =			0.88	m	
	Edge Beam Width =			0.40	m	
	Edge Beam Depth =			0.40	m	
	Diaphragm ,use at centre and Ends. Thickness=			0.25	m	
	Depth of Diap @ cente =			0.57	m	
	Depth of Diap@ end =			0.57	m	
	Number of Intermidiate Diaphragm			1		
	Number of End Diaphragm			2		
	C/C distance b/n Diaphragm =			7.00	m	

3.0.Deck Slab Design

3.1 Design of the Overhanging Slab

3.1.1 Dead Loads and Moments

Item	Weight (KN/m)	Moment arm(m)	Moment (KNm/m)
Barrier Load	3.957	0.69	2.730
Over hang slab load	6.499	0.44	2.860
Wearing surface(DW)	**0.231**	0.775	**0.179**
Total (DC)	**10.456**		**5.590**



3.1.2Live Load on Overhang Slab

According to Art `2.9 and eq 7.14, Wheel loads are applied on an effective length of E =1140+ 0.833X

X - Distance in mm from center of post to point under investigation

Railing Load

X=	0.73	m
E = 1140+ 0.833X =	1748.09	mm
E=	1.75	m
Prail	44.50	KN
M_LL =P/E =	25.46	KN/m
M_LL =P(X/E) =	18.583	KNm/m

According to Art 3.24.5.1 & 3.24.5.2, Wheel loads are applied on an effective length of E =1140+ 0.833X

X - Distance in mm from load to point of support

Truck Load

X =	0.720	m
E = 1140+ 0.833X =	1739.760	mm
E =	1.74	m
M_LL =P/E =	41.67	KN/m
M_LL =P(X/E) =	0.000	KNm/m
M-LL IM=	0.000	KNm/m
lane=	1.042	KNm/m
M-LL tot	1.042	KNm/m

3.1.2 Total moment

$Q = \Sigma \eta_i \gamma_i$ (Here, $\eta_D = \eta_R = 1.00$ $\eta_I = 1.00$ MD = 1.0(1.25 DC +1.5 DW + 1.75 LL+IM)

a) Dead load plus rail live load

$M_{TR} = 1.25M_{DL+}1.5MDW+1.75M_{RLL}$

= 39.776504 kNm/m

b) Dead load plus truck live load

$M_{TT} = 1.25M_{DL+1.5*MDW}+1.75M_{LL}$

= 9.079895 kNm/m

c) Design moment

$M_D = \max(M_{TR}, M_{TT})$

= **39.78** kNm/m

Balanced Steel Ratio=	$\rho_b = \alpha \dfrac{0.003}{\dfrac{fy}{E_S} + 0.003} \dfrac{fc}{fy}$	0.0384		
	Using only r= 0.75r$_b$ =	0.0288		
Depth Required, dreq	$d_{req} = \sqrt{\dfrac{Mu}{\phi\rho\ fy\ b\left(1 - 0.59\rho \dfrac{fy}{fc}\right)}}$ =	87.81	mm	
	Cover =	25.00	mm	
Use Rebars of diameter =		16	mm	
	davailable =	197.00	mm	OK
Area of Reinforcement Required As =	$A_S = \dfrac{M_U}{\Phi f_y (d - (a/2))}$			
	Assume a =	11.32	mm	
	As =	769.94	mm²	
	Check a :			
	$a = \dfrac{A_S f_y}{0.85 f'_C b}$ a =	11.32	mm	OK
	As_req =	769.94	mm²	
	Area of One bar , a_s =	201.06	mm²	
Spacing, S =	$S = \dfrac{1000 a_S}{A_S}$	261.14	mm	
Use diameter 16		mm c/c	260	mm Top
	As_actual =	773.32	mm²	

3.2 Design of interior Slab

C/C of Supports (Girders) =	2.30	m	

Loads on the Slab

3.2.1 Dead Load

Slab = g_C*Df =	7.92	KN/m²
Side Walk	0.00	KN/m²
Wearing Surface =	1.10	KN/m²
Total =	9.02	KN/m²
Total w_DL =	9.02	KN/m²
Continuity Factor K =	0.80	Continuous Supports
M_DL =k*wS²/8 =	4.77	KNm/m
MDW=	0.58	KNm/m

3.2.2 Live Load

3.2.2.1 Vehicular load

When decks are designed using the approximate strip method (Art. 4.6.2.1) and the strips are transverse they shall be designed for the 145KNm axle load (Art. 3.6.1.3.3).

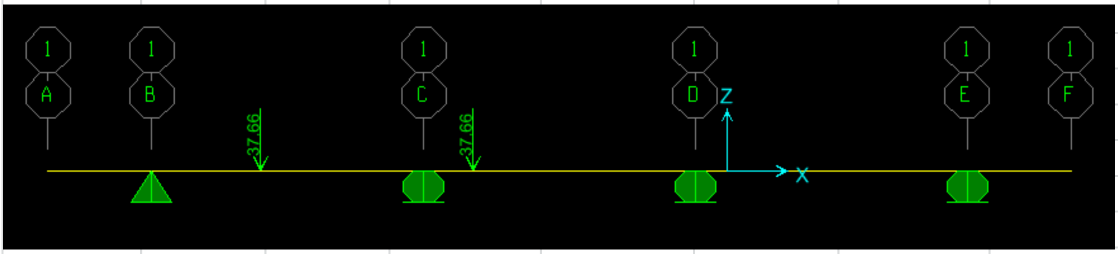
The design truck load shall be positioned transversely to produce maximum force effects.

3.2.2.1.1. Maximum Positive Live Load Moment

For repeating equal spans, the maximum positive bending moment occurs near the 0.4 points of the first interior span.

The equivalent width of the strip over which the live load is applied is:

E=660+0.55Gs =	1.925	m	
Position of the second wheel = 0.4*Gs =	0.92	m	(on the second span)
Position of the second wheel = 0.4*Gs+1.8 =	2.72	m > 2.30 m	(on the second span)
P-LL=	37.66	KN	



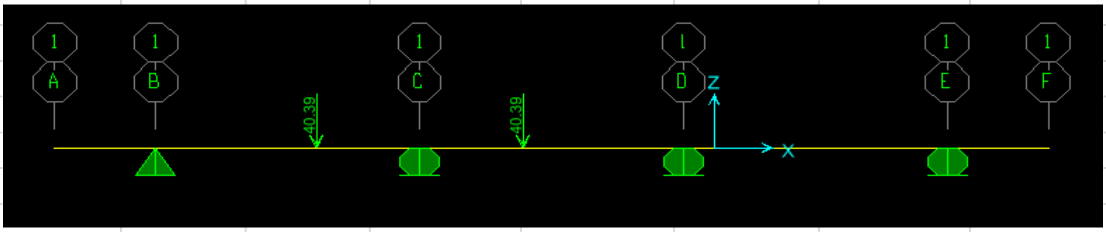
Output from sap		
Max. positive Moment=	15.87	KNm/m
M-LLIM=	21.1071	KNm/m

3.2.2.1.2. Maximum Interior Negative live load moment

The critical placement of live load for maximum negative moment is at the first interior support.

The width of equivalent transverse strip is

E=1220+0.25*Gs	1.80	m
P-LL=	40.39	KN



Output from sap		
Max. negative Moment=	16.12	KNm/m
M-LLIM=	21.4396	KNm/m
Lane load	9.3	KN/m
Lane load moment=	1.64	KNm/m

Design Moment and Reaction Computaions

M=1.0(1.25DC+1.50DW+1.75(LL+IM))

Mpos=	38.50	KNm/m
Mneg=	47.23	KNm/m

Balanced Steel Ratio= $\rho_b = \alpha \dfrac{0.003}{\dfrac{fy}{E_s}+0.003}\dfrac{fc}{fy}$ 0.0384

Using only $r = 0.75r_b$ = 0.0288

Depth Required, dreq $d_{req} = \sqrt{\dfrac{Mu}{\phi\rho\ fy\ b\left(1-0.59\rho\dfrac{fy}{fc}\right)}} =$ 87.81 mm

Top Main Reinforcement

	Cover =	25.00	mm
Use Rebars of diameter =		16	mm
	davailable =	147.00	mm	OK
Area of Reinforcement Required As =	$A_s = \dfrac{M_U}{\Phi f_y (d-(a/2))}$		
	Assume a =	15.03	mm
	As =	1022.35	mm²
	Check a :		
$a = \dfrac{A_s f_y}{0.85 f'_c b}$	a =	15.03	mm	OK
	As_req =	1022.35	mm²
	Area of One bar , a_s =	201.06	mm²
Spacing, S = $S = \dfrac{1000 a_s}{A_s}$		196.67	mm
Use diameter 16	mm c/c	190	mm Top
	As_actual =	1058.22	mm²

Bottom Main Reinforcement

Use Rebars of diameter =		16	mm
	Assume a =	18.68	mm
	As =	1270.61	mm²
	Check a :		
$a = \dfrac{A_s f_y}{0.85 f'_c b}$	a =	18.69	mm	OK
	As_req =	1270.61	mm²
Area of One bar , as =		201.06193	mm²
Spacing, S = $S = \dfrac{1000 a_s}{A_s}$		158.24	mm
Use diamete	16 mm c/c		150 mm Bottom
	As_actual =	1340.41	mm²

Distribution Steel, As_dist =	$A_{s\_dist} = \dfrac{220}{\sqrt{S}} \leq 67\%$	898.08	mm²
	Use Rebars of diameter =	12	mm
	Area of One bar , a_s =	113.10	mm²
Spacing of Diameter	12	bar is	125.93 mm
Use diameter	12	bars c/c	120 mm

Temperature and Shrinkage Reinforcement

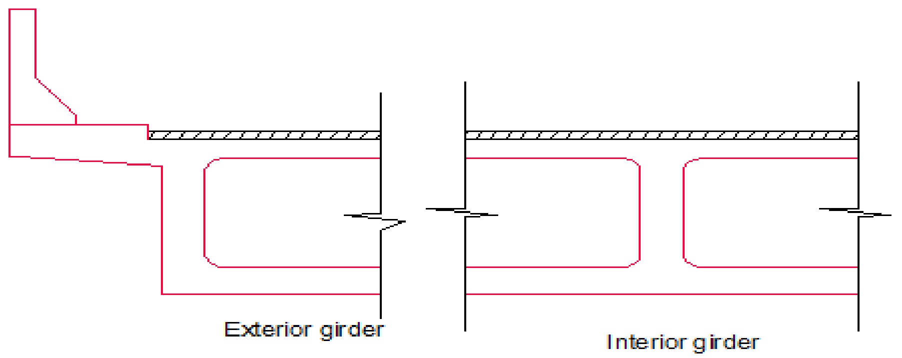
As per AASHTO Art. 8-20,

Provide (1/8)inch²/ft for temperature and shrinkage reinforcement

	As_temp =	0.125	in²/ft
	As_temp =	264.58	mm²/m
Use diameter	12 mm bars		
	a_s =	113.10	mm²
Spacing of Diameter	12	bar is	350 mm
Use Diameter	12	bars c/c	350 mm Top

4.2.2 Longitudinal direction design

4.0. Design of Exterior Girder



4.1. Dead load

4.1.1 Dead load of girder

Item	Weight[KN/m]
overhang	10.456
Top slab(t_s)	4.428
Bottom slab(t_b)	3.690
girder	3.420
wearing surface(DW)	1.496
Total DC	21.994

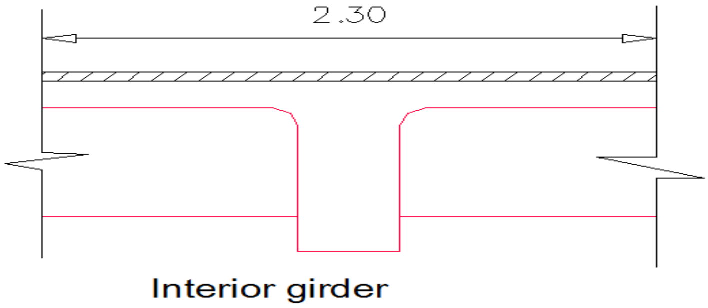
4.1.3 Live load

live load distribution on a girder

Truck	99.1	KN
Tandum	75	KN
Truck loads are therefore		
Front Axel	48	KN
Middle and Rare Wheel Loads	99.1	KN
Lane load for Exterior Girder	5.52	KN/m

4.1 Interior Girder

4.1.1 Dead load



Dead load of interior girder

Item	Weight[KN/m]
Top slab (ts)	9.936
Bottom slab(tb)	8.280
Interior girder	3.420
wearing surface(DW)	2.530
Total DC	21.636

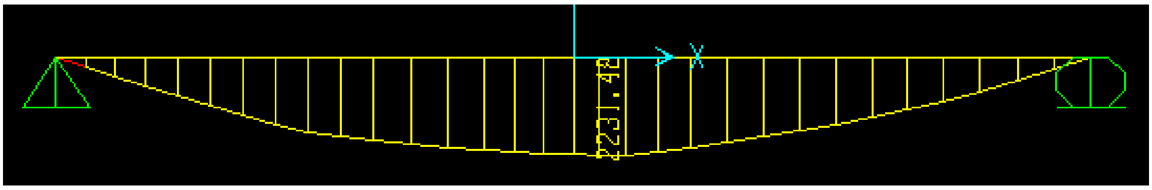
4.2.3 Live load

Live load distribution on a girder

Truck	97.6	KN
Tandum	74	KN
Truck loads are therefore		
Front Axel	47	KN
Middle and Rare Wheel Loads	97.6	KN
Lane load for Interior Girder	7.13	KN/m

4.2.3 Analysis output from sap software

Exterior girder



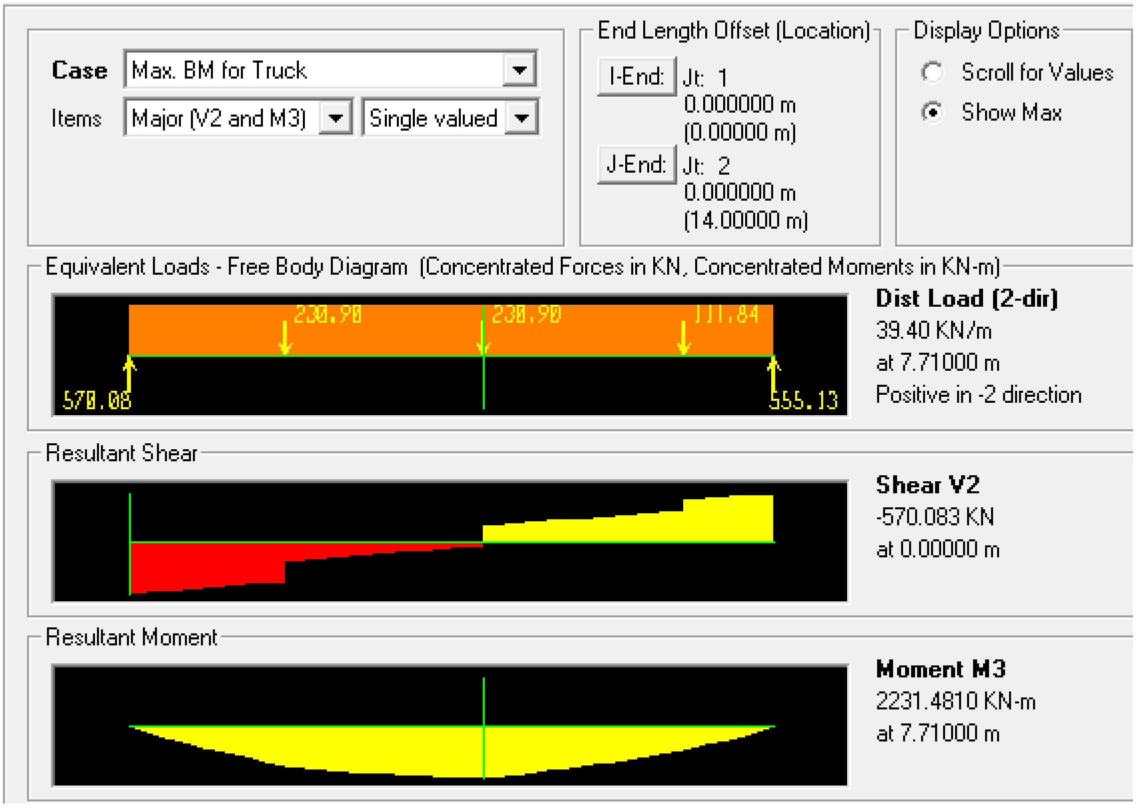


Figure 4-5 Bending Moment and shear force diagram for exterior girder

Interior girder

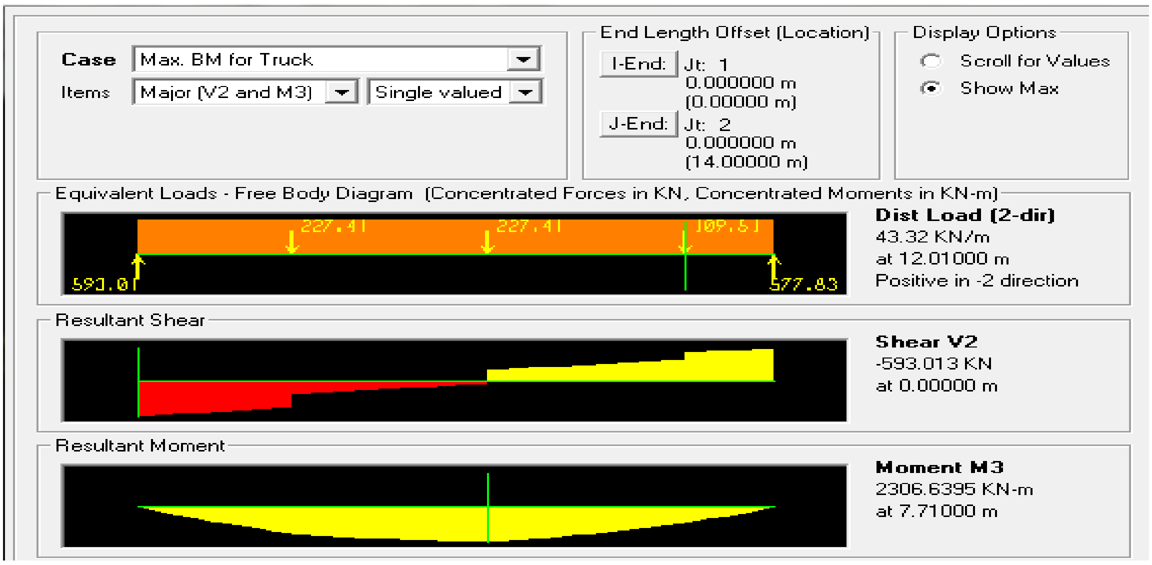


Figure 4-6 Bending Moment and shear force diagram for interior girder

4.2.4 Design for flexural in Exterior and Interior girder

Reinforcement detail in the girder

Table 4-3: Flexural Reinforcement detail

x (m)	Exterior Girder			Interior Girder		
	MD	As	No. of bars	MD	As	No. of bars
2.8	1440.89	4825.486	6Φ32	1489.61	4825.486	6Φ32
4.2	1863.77	7238.229	9Φ32	1928.15	8042.477	10Φ32
5.6	2067.85	8846.725	11Φ32	2142.25	9650.973	12Φ32

Figure 4-7: Comparative Design Moment of exterior and interior girders

Shear reinforcement detail

Table 4-4: Shear Reinforcement detail

Exterior girder Shear reinforcement									
x(m)	Vu	Mu	Assumed θ	e	θ	β	Vs	S	Spacing of bars
1.25	429.7	567.46	36	0.00043	36	1.9	620.325	187.671	Φ 12 c/c 180 mm
1.4	423.8	630.9	37	0.00048	36	1.6	591.191	190.288	Φ 12 c/c 190 mm
2.8	368.6	1185.58	37	0.0009	37	1.55	526.141	210.923	Φ 12 c/c 210 mm
4.2	313.4	1663.23	37	0.00127	37	1.65	472.375	248.043	Φ 12 c/c 240 mm
5.6	27.34	1762.75	36	0.00135	37	1.7	158.258	2843.6	Φ 12 c/c 300 mm
7	27.78	1763.65	36	0.00135	37	1.7	97.0138	2798.57	Φ 12 c/c 300 mm

Interior girder shear reinforcement									
x(m)	Vu	Mu	Assumed θ	e	θ	β	Vs	S	Spacing of bars
1.25	448.9	594.55	36	0.00043	36	1.9	358.761	175.982	Φ 12 c/c 170 mm
1.4	442.4	660.78	37	0.00047	36	1.6	373.645	178.569	Φ 12 c/c 170 mm
2.8	381.8	1237.74	37	0.00089	37	1.55	309.939	199.521	Φ 12 c/c 190 mm
4.2	321.1	1729.99	37	0.00124	37	1.65	235.174	237.21	Φ 12 c/c 230 mm
5.6	33.04	1840.9	36	0.00132	37	1.7	-88.577	2305.33	Φ 12 c/c 300 mm
7	27.61	1846.01	36	0.00132	37	1.7	-94.611	2758.72	Φ 12 c/c 300 mm

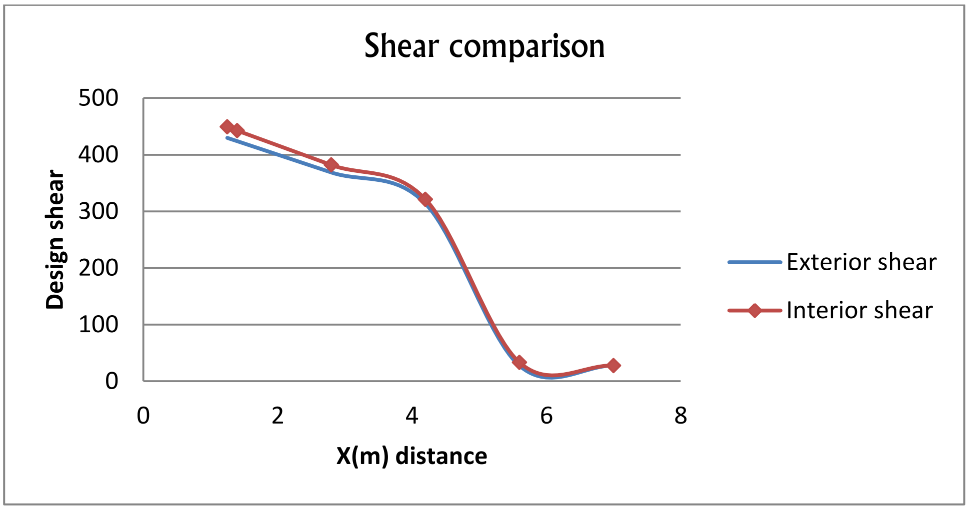


Figure 4-8: Comparative Design shear of exterior and interior girders

4.2.5 Comparison of T- and Box Girder Bridge with Design shear and momentum

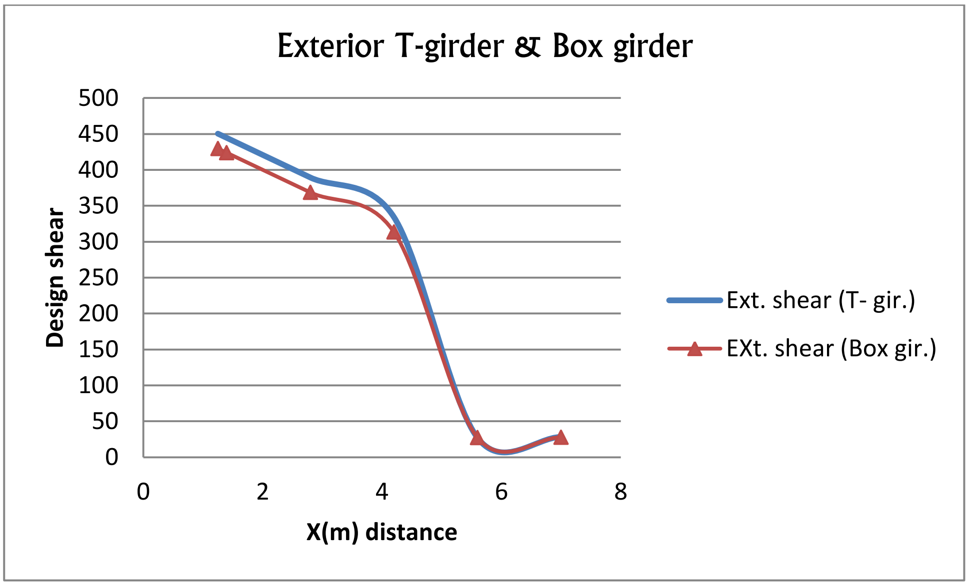


Figure 4-9: Comparative Design shear of exterior girders of both T-and Box girder

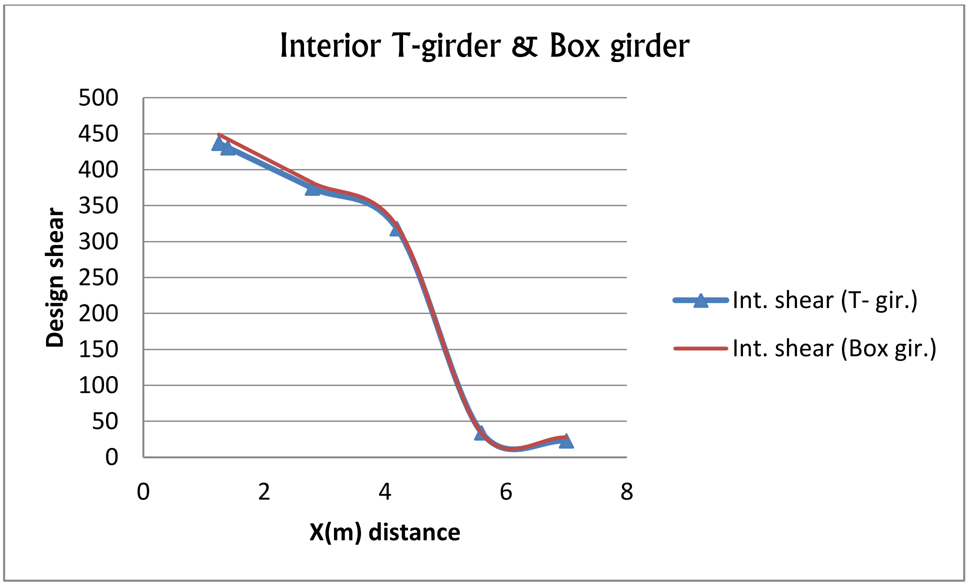


Figure 4-10: Comparative Design shear of interior girders of both T-and Box girder

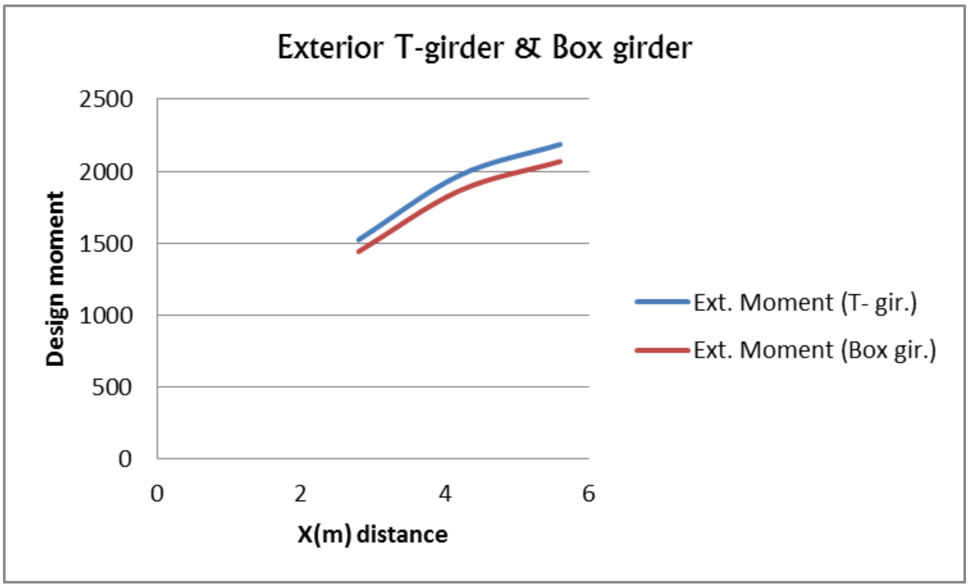


Figure 4-11: Comparative Design moment of exterior girders of both T-and Box girder

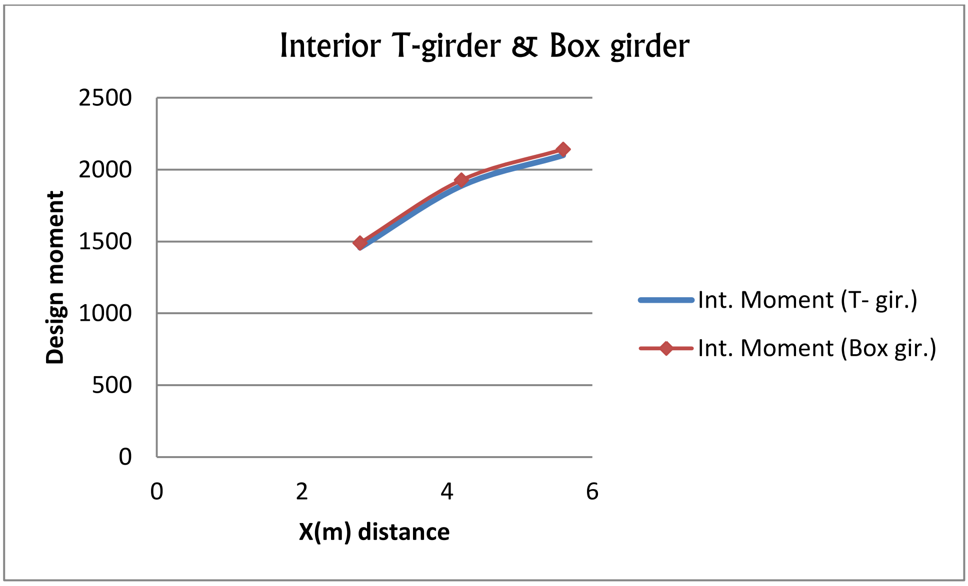


Figure 4-12: Comparative Design moment of interior girders of both T-and Box girder

CHAPTER 5 RESULTS AND DISCUSSION

5.1 Design Output

The design examples showing the whole process of computation for 14 m span T-and Box-girder bridges, are Computed in chapter 4. The summary of necessary outputs obtained for 18m, 24m, 30m, and 34m span T- girder and Box-girder bridges are presented in Table 5.1, 5.2, 5.3 and Table 5.4, respectively.

5.1.1 Limitations

While analyzing the bridge cost, the following are only taken in to account

- ✓ The cost analysis of bridges considers only construction costs.
- ✓ Only the superstructure cost of the bridge is considered for economic analysis since it is assumed that the substructures are almost the same for both T-girder and Box- girder bridges having the same span length.
- ✓ The Analysis is done only for single span bridges

Table 5-1: Summary of Reinforcement for span 14, 18, 24, 30 and 34m of T-Girder Bridges

Span length (m)	Deck slab					Longitudinal reinforcement			
						Exterior Girder		Interior Girder	
	Over hang bar	Top bar	Bottom bar	Distribution bar	Temp. reinforcement	Main bar	Shear bar	Main bar	Shear bar
14	ø16mm c/c 120mm, L=2050	ø16mm c/c 180mm, L=11030	ø16mm c/c 170mm, L=11030	ø12mm c/c 140mm, L=14500	ø12mm c/c 450mm, L=14500	ø32mm No.=10 , L=var.	ø12mm c/c=var., L=2448	ø32mm No.=9 , L=var.	ø12mm c/c=var., L=2448
18	ø16mm c/c 120mm, L=2050	ø16mm c/c 180mm, L=11030	ø16mm c/c 170mm, L=11030	ø12mm c/c 140mm, L=18500	ø12mm c/c 450mm, L=18500	ø32mm No.=11 , L=var.	ø12mm c/c=var., L=3048	ø32mm No.=10 , L=var.	ø12mm c/c=var., L=3048
24	ø16mm c/c 120mm, L=2050	ø16mm c/c 180mm, L=11030	ø16mm c/c 170mm, L=11030	ø12mm c/c 140mm, L=24500	ø12mm c/c 450mm, L=24500	ø32mm No.=13 , L=var.	ø12mm c/c=var., L=3848	ø32mm No.=13 , L=var.	ø12mm c/c=var., L=3848
30	ø16mm c/c 120mm, L=2050	ø16mm c/c 180mm, L=11030	ø16mm c/c 170mm, L=11030	ø12mm c/c 140mm, L=30500	ø12mm c/c 450mm, L=30500	ø32mm No.=19 , L=var.	ø12mm c/c=var., L=4648	ø32mm No.=18 , L=var.	ø12mm c/c=var., L=4648
34	ø16mm c/c 120mm, L=2050	ø16mm c/c 180mm, L=11030	ø16mm c/c 170mm, L=11030	ø12mm c/c 140mm, L=34500	ø12mm c/c 450mm, L=34500	ø32mm No.=20 , L=var.	ø12mm c/c=var., L=5248	ø32mm No.=21 , L=var.	ø12mm c/c=var., L=5248

Table 5-2: Summary of Outputs for span length 14, 18, 24, 30 and 34m of T-Girder Bridges

Span length (m)	**Deck slab thickness (m)**	Girder dimension(m)		Reinforcement quantity(Kg)	Volume of Concrete(m3)	Area of form work (m2)	
		Web width(m)	Depth(m)			Class F1	Class F2
14	0.20	0.38	1.00	7935.89	51.13	113.12	188.63
18	0.20	0.38	1.30	10136.46	75.82	145.44	300.20
24	0.2	0.38	1.70	16334.88	116.07	193.92	479.55
30	0.2	0.38	2.10	22051.92	166.20	242.40	718.04
34	0.2	0.38	2.40	26497.13	207.33	274.72	922.79

Table 5-3: Summary of Reinforcement for span 14, 18, 24, 30 and 34m of Box Girder Bridges

Reinforcements												
Span leng. (m)	Deck slab					Bottom slab			Longitudinal reinforcement			
									Exterior Girder		Interior Girder	
	Over hang bar	Top bar	Bottom bar	Distribution bar	Temp. bar	Longitudinal direction	Traversal direction	Temp. bar(both direction)	Main bar	Shear bar	Main bar	Shear bar
14	ø16mm c/c 120mm, L=2050	ø16mm c/c 190mm, L=11030	ø16mm c/c 150mm, L=11030	ø16mm c/c 120mm, L=14500	ø12mm c/c 450mm, L=14500	ø16mm c/c 350mm, L=14500	ø16mm c/c 280mm, L=6650	ø12mm c/c 450mm, L=6650 & 14000	ø32mm No.=11 , L=var.	ø12mm c/c=var. L=2118	ø32mm No.=12 , L=var.	ø12mm c/c=var. L=2118
18	ø16mm c/c 120mm, L=2050	ø16mm c/c 190mm, L=11030	ø16mm c/c 150mm, L=11030	ø16mm c/c 120mm, L=14500	ø12mm c/c 450mm, L=18500	ø16mm c/c 350mm, L=18500	ø16mm c/c 280mm, L=6650	ø12mm c/c 450mm, L=6650 & 14000	ø32mm No.=12 , L=var.	ø12mm c/c=var., L=2518	ø32mm No.=13 , L=var.	ø12mm c/c=var., L=2518
24	ø16mm c/c 120mm, L=2050	ø16mm c/c 190mm, L=11030	ø16mm c/c 150mm, L=11030	ø16mm c/c 120mm, L=24500	ø12mm c/c 450mm, L=24500	ø16mm c/c 350mm, L=24500	ø16mm c/c 280mm, L=6650	ø12mm c/c 450mm, L=6650 & 14000	ø32mm No.=14 , L=var.	ø12mm c/c=var., L=3318	ø32mm No.=15 , L=var.	ø12mm c/c=var., L=3318
30	ø16mm c/c 120mm, L=2050	ø16mm c/c 190mm, L=11030	ø16mm c/c 150mm, L=11030	ø16mm c/c 120mm, L=30500	ø12mm c/c 450mm, L=30500	ø16mm c/c 350mm, L=30500	ø16mm c/c 280mm, L=6650	ø12mm c/c 450mm, L=6650 & 14000	ø32mm No.=20 , L=var.	ø12mm c/c=var., L=3918	ø32mm No.=21 , L=var.	ø12mm c/c=var., L=3918
34	ø16mm c/c 120mm, L=2050	ø16mm c/c 190mm, L=11030	ø16mm c/c 150mm, L=11030	ø16mm c/c 120mm, L=34500	ø12mm c/c 450mm, L=34500	ø16mm c/c 350mm, L=34500	ø16mm c/c 280mm, L=6650	ø12mm c/c 450mm, L=6650 & 14000	ø32mm No.=20 , L=var.	ø12mm c/c=var., L=4518	ø32mm No.=21 , L=var.	ø12mm c/c=var., L=4518

Table 5-4: Summary of Outputs for span length 14, 18, 24, 30 and 34m of Box Girder Bridges

Span length (m)	Deck slab thickness (m)		Girder dimension(m)		Reinforcement quantity (Kg)	Volume of Concrete (m3)	Area of form work (m2)	
	Top flange(m)	Bottom flange (m)	Web width (m)	Depth (m)			Class F1	Class F2
14	0.18	0.15	0.25	0.90	10711.50	43.85	213.36	146.44
18	0.18	0.15	0.25	1.10	13855.48	59.98	274.32	217.08
24	0.18	0.15	0.25	1.50	19576.77	89.58	365.76	366.24
30	0.18	0.15	0.25	1.80	25602.62	120.97	457.20	529.80
34	0.18	0.15	0.25	2.10	28502.33	139.62	518.16	682.04

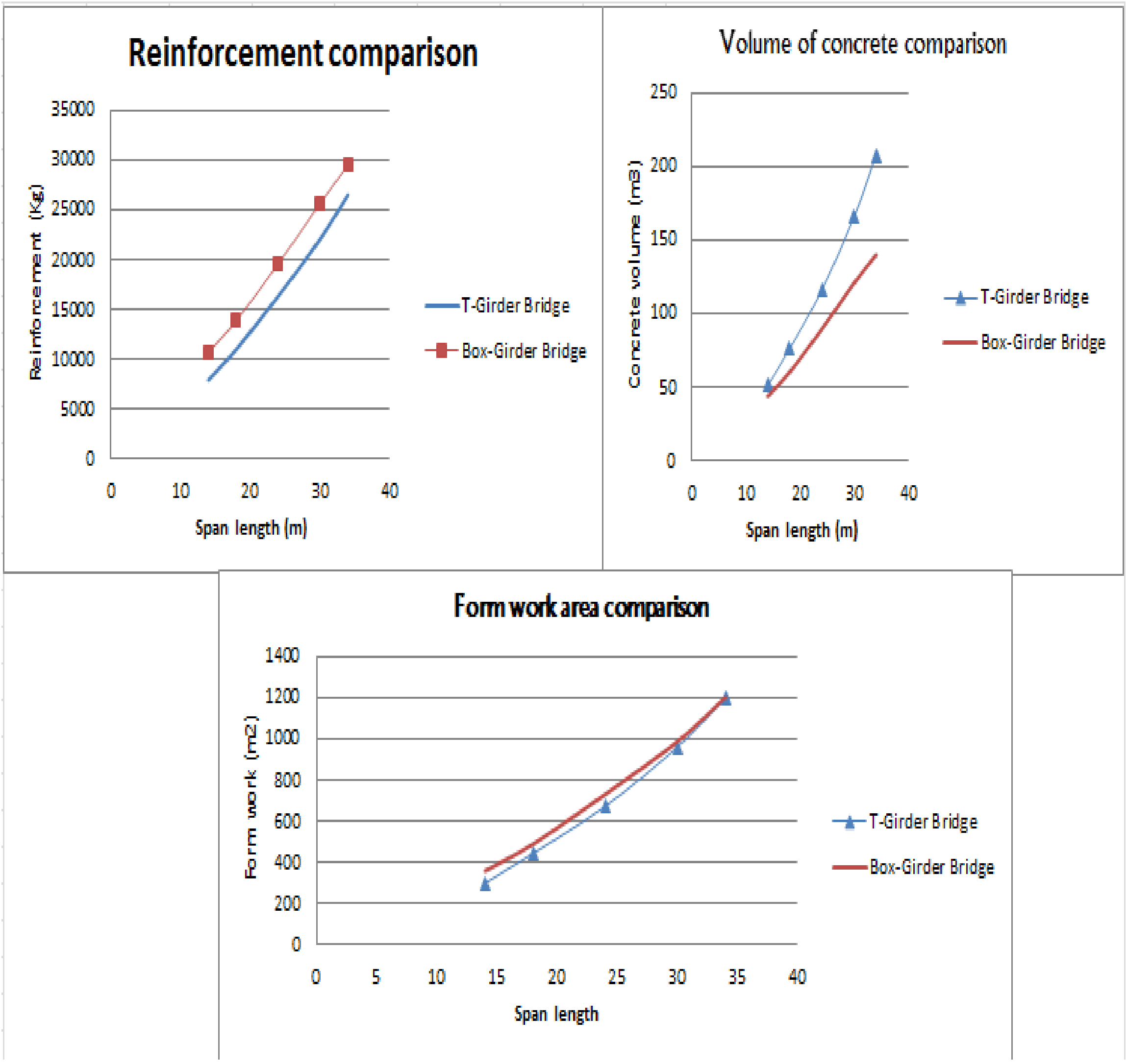


Figure 5-1: Quantity of T-girder vs Box girder by graphs

5.1.2 Results

The quantity of materials obtained from the output and current materials market prices are used for the economical span of the two types of bridges (T- and Box Girder Bridges).

For economical span, recent values of construction costs of materials including overhead cost are used here. Table 5.5 below shows the cost for different materials.

Table 5-5: Unit Price for Construction Materials

No.	Type of material	Unit	Rate (Birr)
1	High yield stress steel bars (Fy=420Mpa)	Kg	32
2	Cast in situ concrete (C-30Mpa)	m^3	4200
3	Formworks to provide Class f1	m^2	480
4	Formworks to provide Class f2	m^2	645
4	Asphalt concrete	m^2	320
5	Elastomeric bearing	No.	15,000

An output of the results of the two types of bridges for span ranges from 14m,18m, 24m, 30m and 34m and their total associated costs of the superstructure are summarized and tabulated in Table 5.6 below.

Table 5-6: Total Superstructure Costs for Different Span Lengths

No.	Span length (m)	Total Superstructure cost (Birr)	
		T-Girder Bridge	Box Girder Bridge
1	14	810,756.07	876,616.34
2	18	1,085,512.79	1,129,162.12
3	24	1,611,616.70	1,590,694.83
4	30	2,201,988.87	2,078,821.52
5	34	2,677,691.84	2,386,766.68

Figure 5.2: shows a relationship between span length and total cost of superstructure for span length of a bridge ranging from 14m, 18m, 24m, 30m and 34m

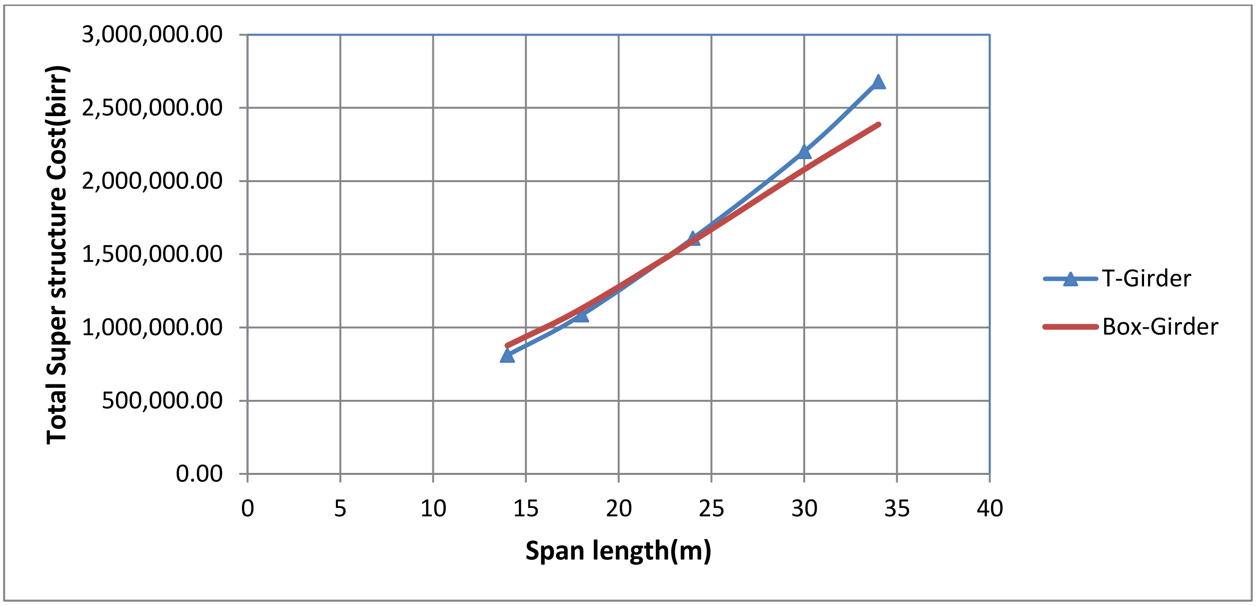


Figure 5-2: Span Length vs Total Superstructure Cost

5.1.3 Discussions

- As summarized output data from Table 5.1 & 5.2, the area of formwork of a T-Girder bridge for class F_2 finish is much larger than those in Box-Girder bridges due to larger area of structural components' exposed faces. Hence, it gives considerable contribution for increment of the total cost of a T-Girder bridge.
- Again from Table 5.1 & 5.2, the total cost of a T-Girder bridge is also governed by its' larger volume of concrete than in a Box-Girder bridge, which is directly related to larger structural depth and width of girders.
- From the tabulated output data and graphical description one can easily understand , the economical span of the two types of bridges (T- girder & Box girder) at time of completion of the study is 20.2m.
- Cost of construction differs from time to time due to the variability in price of construction materials, skilled & unskilled workers, and other associated factors. For these reason, the economical span of the two types of bridges can vary with time accordingly.

CHAPTER 6 CONCLUSIONS AND RECCOMENDATIONS

6.1 Conclusion

Per the observation of the result from Table 5.4 and Figure 5.2 of cost comparison for superstructures of the two types of bridges using the prevailing cost, it is found that a span of 21m is the demarcation span for selecting T-Girder or Box-Girder Bridge. Thus, up to 21m T-Girder Bridge is economical whereas beyond 21m Box-Girder Bridge is economical.

Since exposed faces of structural components of a T-Girder bridge is much larger than those in Box-Girder bridges, it is observed that the area of formwork for class F_2 finish is much bigger, hence, it gives considerable contribution for increment of the total cost of a T-Girder bridge. Furthermore, the total cost of a T-Girder bridge is also governed by the total volume of concrete, which is higher than those in Box Girder Bridge due to larger structural depth and width of girders.

6.2 Recommendations

From the study that has been conducted, the followings recommendations are drawn from the result:

- ✓ The economical span that of the two types of bridges (T- girder & Box Girder bridges) is **21**m. Accordingly, T-Girder Bridge is economical up to **21**m and that of the Box-Girder Bridge is economical beyond **21**m.

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APPENDIX A

Output from sap2000V14 software
T-Girder Bridge Exterior and Interior analysis
Clear Span length 14m

Exterior girder

TABLE: Element Forces - Frames

Station(m)	OutputCase	CaseType	V2(KN)	M3(KNm)
0	Max. BM	Comb.	-599.456	-1.786E-13
0.4	Max. BM	Comb.	-583.699	236.631
0.8	Max. BM	Comb.	-567.942	466.9593
1.2	Max. BM	Comb.	-552.185	690.9847
1.2	Max. BM	Comb.	-552.185	690.9847
1.642	Max. BM	Comb.	-534.774	931.2026
2.084	Max. BM	Comb.	-517.362	1163.7246
2.526	Max. BM	Comb.	-499.951	1388.5507
2.968	Max. BM	Comb.	-482.539	1605.6809
3.41	Max. BM	Comb.	-465.128	1815.1153
3.41	Max. BM	Comb.	-213.022	1815.1153
3.855	Max. BM	Comb.	-195.492	1906.0096
4.3	Max. BM	Comb.	-177.962	1989.1032
4.3	Max. BM	Comb.	-177.962	1989.1032
4.8	Max. BM	Comb.	-158.266	2073.1603
5.3	Max. BM	Comb.	-138.57	2147.3692
5.8	Max. BM	Comb.	-118.874	2211.7301
5.8	Max. BM	Comb.	-118.874	2211.7301
6.2	Max. BM	Comb.	-103.117	2256.1281
6.6	Max. BM	Comb.	-87.36	2294.2234
7	Max. BM	Comb.	-71.603	2326.0158
7	Max. BM	Comb.	-66.565	2326.0158
7.355	Max. BM	Comb.	-52.581	2347.1642
7.71	Max. BM	Comb.	-38.596	2363.3481
7.71	Max. BM	Comb.	213.51	2363.3481
8.155	Max. BM	Comb.	231.039	2264.436
8.6	Max. BM	Comb.	248.569	2157.7232
8.6	Max. BM	Comb.	248.569	2157.7232
9.087	Max. BM	Comb.	267.759	2031.9605
9.574	Max. BM	Comb.	286.948	1896.8497
10.06	Max. BM	Comb.	306.138	1752.3908
10.55	Max. BM	Comb.	325.328	1598.5836
11.04	Max. BM	Comb.	344.518	1435.4283
11.52	Max. BM	Comb.	363.708	1262.9249
12.01	Max. BM	Comb.	382.897	1081.0732
12.01	Max. BM	Comb.	504.057	1081.0732
12.51	Max. BM	Comb.	523.655	825.4298
13.01	Max. BM	Comb.	543.253	560.0364
13.5	Max. BM	Comb.	562.851	284.8931
14	Max. BM	Comb.	582.448	-3.057E-12
0	Service BM	Comb.	-388.397	-1.182E-13
0.4	Service BM	Comb.	-376.795	153.0384
0.8	Service BM	Comb.	-365.192	301.4358
1.2	Service BM	Comb.	-353.59	445.1922
1.2	Service BM	Comb.	-353.59	445.1922
1.642	Service BM	Comb.	-340.769	598.6456
2.084	Service BM	Comb.	-327.949	746.4323
2.526	Service BM	Comb.	-315.128	888.5522

Interior girder

TABLE: Element Forces - Frames

Station(m)	OutputCase	CaseType	V2(KN)	M3(KNm)
0	Max. BM	Com.	-577.138	-1.893E-13
0.4	Max. BM	Com.	-561.004	227.6283
0.8	Max. BM	Com.	-544.87	448.8029
1.2	Max. BM	Com.	-528.736	663.524
1.2	Max. BM	Com.	-528.736	663.524
1.642	Max. BM	Com.	-510.908	893.2851
2.084	Max. BM	Com.	-493.079	1115.1663
2.526	Max. BM	Com.	-475.251	1329.1674
2.968	Max. BM	Com.	-457.423	1535.2885
3.41	Max. BM	Com.	-439.595	1733.5296
3.41	Max. BM	Com.	-212.187	1733.5296
3.855	Max. BM	Com.	-194.238	1823.9593
4.3	Max. BM	Com.	-176.289	1906.4017
4.3	Max. BM	Com.	-176.289	1906.4017
4.8	Max. BM	Com.	-156.122	1989.5043
5.3	Max. BM	Com.	-135.954	2062.5233
5.8	Max. BM	Com.	-115.787	2125.4585
5.8	Max. BM	Com.	-115.787	2125.4585
6.2	Max. BM	Com.	-99.653	2168.5463
6.6	Max. BM	Com.	-83.519	2205.1806
7	Max. BM	Com.	-67.385	2235.3613
7	Max. BM	Com.	-57.31	2235.3613
7.355	Max. BM	Com.	-42.991	2253.1646
7.71	Max. BM	Com.	-28.672	2265.8847
7.71	Max. BM	Com.	198.736	2265.8847
8.155	Max. BM	Com.	216.685	2173.4534
8.6	Max. BM	Com.	234.634	2073.0348
8.6	Max. BM	Com.	234.634	2073.0348
9.087	Max. BM	Com.	254.283	1953.9484
9.574	Max. BM	Com.	273.932	1825.2902
10.06	Max. BM	Com.	293.581	1687.0602
10.55	Max. BM	Com.	313.23	1539.2583
11.04	Max. BM	Com.	332.879	1381.8847
11.52	Max. BM	Com.	352.528	1214.9392
12.01	Max. BM	Com.	372.177	1038.4219
12.01	Max. BM	Com.	481.687	1038.4219
12.51	Max. BM	Com.	501.753	793.7912
13.01	Max. BM	Com.	521.82	539.1773
13.5	Max. BM	Com.	541.887	274.5802
14	Max. BM	Com.	561.953	5.139E-13
0	Service BM	Com.	-577.138	-1.893E-13
0.4	Service BM	Com.	-561.004	227.6283
0.8	Service BM	Com.	-544.87	448.8029
1.2	Service BM	Com.	-528.736	663.524
1.2	Service BM	Com.	-528.736	663.524
1.642	Service BM	Com.	-510.908	893.2851
2.084	Service BM	Com.	-493.079	1115.1663
2.526	Service BM	Com.	-475.251	1329.1674

2.968	Service BM	Comb.	-302.307	1025.0054	2.968	Service BM	Com.	-457.423	1535.2885
3.41	Service BM	Comb.	-289.487	1155.7918	3.41	Service BM	Com.	-439.595	1733.5296
3.41	Service BM	Comb.	-145.581	1155.7918	3.41	Service BM	Com.	-212.187	1733.5296
3.855	Service BM	Comb.	-132.673	1217.7033	3.855	Service BM	Com.	-194.238	1823.9593
4.3	Service BM	Comb.	-119.765	1273.8708	4.3	Service BM	Com.	-176.289	1906.4017
4.3	Service BM	Comb.	-119.765	1273.8708	4.3	Service BM	Com.	-176.289	1906.4017
4.8	Service BM	Comb.	-105.262	1330.1277	4.8	Service BM	Com.	-156.122	1989.5043
5.3	Service BM	Comb.	-90.759	1379.1331	5.3	Service BM	Com.	-135.954	2062.5233
5.8	Service BM	Comb.	-76.256	1420.887	5.8	Service BM	Com.	-115.787	2125.4585
5.8	Service BM	Comb.	-76.256	1420.887	5.8	Service BM	Com.	-115.787	2125.4585
6.2	Service BM	Comb.	-64.654	1449.0691	6.2	Service BM	Com.	-99.653	2168.5463
6.6	Service BM	Comb.	-53.052	1472.6102	6.6	Service BM	Com.	-83.519	2205.1806
7	Service BM	Comb.	-41.449	1491.5103	7	Service BM	Com.	-67.385	2235.3613
7	Service BM	Comb.	-37.419	1491.5103	7	Service BM	Com.	-57.31	2235.3613
7.355	Service BM	Comb.	-27.122	1502.9663	7.355	Service BM	Com.	-42.991	2253.1646
7.71	Service BM	Comb.	-16.825	1510.7669	7.71	Service BM	Com.	-28.672	2265.8847
7.71	Service BM	Comb.	127.081	1510.7669	7.71	Service BM	Com.	198.736	2265.8847
8.155	Service BM	Comb.	139.989	1451.3438	8.155	Service BM	Com.	216.685	2173.4534
8.6	Service BM	Comb.	152.896	1386.1769	8.6	Service BM	Com.	234.634	2073.0348
8.6	Service BM	Comb.	152.896	1386.1769	8.6	Service BM	Com.	234.634	2073.0348
9.087	Service BM	Comb.	167.027	1308.2528	9.087	Service BM	Com.	254.283	1953.9484
9.574	Service BM	Comb.	181.157	1223.4453	9.574	Service BM	Com.	273.932	1825.2902
10.06	Service BM	Comb.	195.287	1131.7545	10.06	Service BM	Com.	293.581	1687.0602
10.55	Service BM	Comb.	209.417	1033.1803	10.55	Service BM	Com.	313.23	1539.2583
11.04	Service BM	Comb.	223.547	927.7227	11.04	Service BM	Com.	332.879	1381.8847
11.52	Service BM	Comb.	237.677	815.3818	11.52	Service BM	Com.	352.528	1214.9392
12.01	Service BM	Comb.	251.807	696.1575	12.01	Service BM	Com.	372.177	1038.4219
12.01	Service BM	Comb.	320.967	696.1575	12.01	Service BM	Com.	481.687	1038.4219
12.51	Service BM	Comb.	335.397	532.8869	12.51	Service BM	Com.	501.753	793.7912
13.01	Service BM	Comb.	349.828	362.4371	13.01	Service BM	Com.	521.82	539.1773
13.5	Service BM	Comb.	364.258	184.8081	13.5	Service BM	Com.	541.887	274.5802
14	Service BM	Comb.	378.689	-1.905E-12	14	Service BM	Com.	561.953	5.139E-13

T-Girder Bridge Exterior and Interior analysis

Clear Span length 18m

Exterior girder

TABLE: Element Forces - Frames

Station(m)	OutputCase	CaseType	V2(KN)	M3(KNm)
0	Max. BM	Comb.	-589.11	1.928E-13
0.4	Max. BM	Comb.	-571.985	232.2189
0.8	Max. BM	Comb.	-554.86	457.5879
1.2	Max. BM	Comb.	-537.735	676.1068
1.2	Max. BM	Comb.	-537.735	676.1068
1.643	Max. BM	Comb.	-518.775	910.0483
2.086	Max. BM	Comb.	-499.815	1135.5932
2.529	Max. BM	Comb.	-480.855	1352.7417
2.971	Max. BM	Comb.	-461.896	1561.4937
3.414	Max. BM	Comb.	-442.936	1761.8492
3.857	Max. BM	Comb.	-423.976	1953.8082
4.3	Max. BM	Comb.	-405.016	2137.3707
4.3	Max. BM	Comb.	-405.016	2137.3707
4.67	Max. BM	Comb.	-389.175	2284.2962
5.04	Max. BM	Comb.	-373.335	2425.3606
5.41	Max. BM	Comb.	-357.494	2560.5639
5.41	Max. BM	Comb.	-357.494	2560.5639
5.888	Max. BM	Comb.	-337.03	2726.5552
6.366	Max. BM	Comb.	-316.565	2882.7645

Interior girder

TABLE: Element Forces - Frames

Station(m)	OutputCase	CaseType
0	Max. BM	Comb.
0.4	Max. BM	Comb.
0.8	Max. BM	Comb.
1.2	Max. BM	Comb.
1.2	Max. BM	Comb.
1.643	Max. BM	Comb.
2.086	Max. BM	Comb.
2.529	Max. BM	Comb.
2.971	Max. BM	Comb.
3.414	Max. BM	Comb.
3.857	Max. BM	Comb.
4.3	Max. BM	Comb.
4.3	Max. BM	Comb.
4.67	Max. BM	Comb.
5.04	Max. BM	Comb.
5.41	Max. BM	Comb.
5.41	Max. BM	Comb.
5.888	Max. BM	Comb.
6.366	Max. BM	Comb.

6.844	Max. BM	Comb.	-296.101	3029.1918	6.844	Max. BM	Comb.
7.322	Max. BM	Comb.	-275.637	3165.8371	7.322	Max. BM	Comb.
7.8	Max. BM	Comb.	-255.172	3292.7005	7.8	Max. BM	Comb.
7.8	Max. BM	Comb.	-64.112	3292.7005	7.8	Max. BM	Comb.
8.2	Max. BM	Comb.	-46.987	3314.9204	8.2	Max. BM	Comb.
8.6	Max. BM	Comb.	-29.862	3330.2903	8.6	Max. BM	Comb.
8.6	Max. BM	Comb.	-29.862	3330.2903	8.6	Max. BM	Comb.
9	Max. BM	Comb.	-12.737	3338.8103	9	Max. BM	Comb.
9	Max. BM	Comb.	178.323	3338.8103	9	Max. BM	Comb.
9.355	Max. BM	Comb.	193.521	3272.808	9.355	Max. BM	Comb.
9.71	Max. BM	Comb.	208.72	3201.4103	9.71	Max. BM	Comb.
9.71	Max. BM	Comb.	208.72	3201.4103	9.71	Max. BM	Comb.
10.19	Max. BM	Comb.	229.174	3096.8023	10.19	Max. BM	Comb.
10.67	Max. BM	Comb.	249.629	2982.4214	10.67	Max. BM	Comb.
11.14	Max. BM	Comb.	270.084	2858.2676	11.14	Max. BM	Comb.
11.62	Max. BM	Comb.	290.539	2724.341	11.62	Max. BM	Comb.
12.1	Max. BM	Comb.	310.994	2580.6415	12.1	Max. BM	Comb.
12.58	Max. BM	Comb.	331.449	2427.1691	12.58	Max. BM	Comb.
13.05	Max. BM	Comb.	351.904	2263.9238	13.05	Max. BM	Comb.
13.53	Max. BM	Comb.	372.358	2090.9057	13.53	Max. BM	Comb.
14.01	Max. BM	Comb.	392.813	1908.1147	14.01	Max. BM	Comb.
14.01	Max. BM	Comb.	392.813	1908.1147	14.01	Max. BM	Comb.
14.51	Max. BM	Comb.	414.166	1706.8742	14.51	Max. BM	Comb.
15.01	Max. BM	Comb.	435.519	1494.9841	15.01	Max. BM	Comb.
15.51	Max. BM	Comb.	456.871	1272.4442	15.51	Max. BM	Comb.
16.01	Max. BM	Comb.	478.224	1039.2547	16.01	Max. BM	Comb.
16.5	Max. BM	Comb.	499.577	795.4156	16.5	Max. BM	Comb.
17	Max. BM	Comb.	520.93	540.9267	17	Max. BM	Comb.
17.5	Max. BM	Comb.	542.282	275.7882	17.5	Max. BM	Comb.
18	Max. BM	Comb.	563.635	-4.923E-13	18	Max. BM	Comb.
0	Service BM	Comb.	-467.939	3.553E-14	0	Service BM	Comb.
0.4	Service BM	Comb.	-455.243	184.6364	0.4	Service BM	Comb.
0.8	Service BM	Comb.	-442.546	364.1941	0.8	Service BM	Comb.
1.2	Service BM	Comb.	-429.849	538.6731	1.2	Service BM	Comb.
1.2	Service BM	Comb.	-429.849	538.6731	1.2	Service BM	Comb.
1.643	Service BM	Comb.	-415.792	725.9221	1.643	Service BM	Comb.
2.086	Service BM	Comb.	-401.735	906.9459	2.086	Service BM	Comb.
2.529	Service BM	Comb.	-387.678	1081.7443	2.529	Service BM	Comb.
2.971	Service BM	Comb.	-373.62	1250.3174	2.971	Service BM	Comb.
3.414	Service BM	Comb.	-359.563	1412.6651	3.414	Service BM	Comb.
3.857	Service BM	Comb.	-345.506	1568.7876	3.857	Service BM	Comb.
4.3	Service BM	Comb.	-331.449	1718.6847	4.3	Service BM	Comb.
4.3	Service BM	Comb.	-331.449	1718.6847	4.3	Service BM	Comb.
4.67	Service BM	Comb.	-319.704	1839.1481	4.67	Service BM	Comb.
5.04	Service BM	Comb.	-307.96	1955.2659	5.04	Service BM	Comb.
5.41	Service BM	Comb.	-296.215	2067.0383	5.41	Service BM	Comb.
5.41	Service BM	Comb.	-152.309	2067.0383	5.41	Service BM	Comb.
5.888	Service BM	Comb.	-137.137	2136.2158	5.888	Service BM	Comb.
6.366	Service BM	Comb.	-121.964	2198.1408	6.366	Service BM	Comb.
6.844	Service BM	Comb.	-106.791	2252.8133	6.844	Service BM	Comb.
7.322	Service BM	Comb.	-91.619	2300.2332	7.322	Service BM	Comb.
7.8	Service BM	Comb.	-76.446	2340.4005	7.8	Service BM	Comb.
7.8	Service BM	Comb.	-76.446	2340.4005	7.8	Service BM	Comb.
8.2	Service BM	Comb.	-63.749	2368.4395	8.2	Service BM	Comb.
8.6	Service BM	Comb.	-51.052	2391.3998	8.6	Service BM	Comb.
8.6	Service BM	Comb.	-51.052	2391.3998	8.6	Service BM	Comb.
9	Service BM	Comb.	-38.355	2409.2813	9	Service BM	Comb.
9	Service BM	Comb.	-38.355	2409.2813	9	Service BM	Comb.
9.355	Service BM	Comb.	-27.087	2420.8973	9.355	Service BM	Comb.
9.71	Service BM	Comb.	-15.819	2428.5131	9.71	Service BM	Comb.
9.71	Service BM	Comb.	128.087	2428.5131	9.71	Service BM	Comb.
10.19	Service BM	Comb.	143.253	2363.6929	10.19	Service BM	Comb.

10.67	Service BM	Comb.	158.419	2291.6269	10.67	Service BM	Comb.
11.14	Service BM	Comb.	173.584	2212.3151	11.14	Service BM	Comb.
11.62	Service BM	Comb.	188.75	2125.7575	11.62	Service BM	Comb.
12.1	Service BM	Comb.	203.916	2031.9541	12.1	Service BM	Comb.
12.58	Service BM	Comb.	219.081	1930.9049	12.58	Service BM	Comb.
13.05	Service BM	Comb.	234.247	1822.6099	13.05	Service BM	Comb.
13.53	Service BM	Comb.	249.412	1707.0691	13.53	Service BM	Comb.
14.01	Service BM	Comb.	264.578	1584.2825	14.01	Service BM	Comb.
14.01	Service BM	Comb.	333.738	1584.2825	14.01	Service BM	Comb.
14.51	Service BM	Comb.	349.569	1413.8827	14.51	Service BM	Comb.
15.01	Service BM	Comb.	365.401	1235.5871	15.01	Service BM	Comb.
15.51	Service BM	Comb.	381.232	1049.3956	15.51	Service BM	Comb.
16.01	Service BM	Comb.	397.063	855.3082	16.01	Service BM	Comb.
16.5	Service BM	Comb.	412.895	653.325	16.5	Service BM	Comb.
17	Service BM	Comb.	428.726	443.4459	17	Service BM	Comb.
17.5	Service BM	Comb.	444.557	225.6709	17.5	Service BM	Comb.
18	Service BM	Comb.	460.389	1.639E-12	18	Service BM	Comb.

T-Girder Bridge Exterior and Interior analysis
Clear Span length 24m

Exterior girder

TABLE: Element Forces - Frames				
Station(m)	OutputCase	CaseType	V2(KN)	M3(KNm)
0	Max.BM	Comb.	-779.158	9.328E-13
0.4	Max.BM	Comb.	-760.209	307.8734
0.8	Max.BM	Comb.	-741.26	608.1672
1.2	Max.BM	Comb.	-722.311	900.8814
1.2	Max.BM	Comb.	-722.311	900.8814
1.643	Max.BM	Comb.	-701.332	1216.1166
2.086	Max.BM	Comb.	-680.353	1522.061
2.529	Max.BM	Comb.	-659.373	1818.7145
2.971	Max.BM	Comb.	-638.394	2106.0773
3.414	Max.BM	Comb.	-617.415	2384.1492
3.857	Max.BM	Comb.	-596.436	2652.9303
4.3	Max.BM	Comb.	-575.456	2912.4206
4.3	Max.BM	Comb.	-575.456	2912.4206
4.763	Max.BM	Comb.	-553.546	3173.5025
5.225	Max.BM	Comb.	-531.637	3424.4511
5.688	Max.BM	Comb.	-509.727	3665.2665
6.15	Max.BM	Comb.	-487.817	3895.9485
6.613	Max.BM	Comb.	-465.907	4116.4973
7.075	Max.BM	Comb.	-443.998	4326.9128
7.538	Max.BM	Comb.	-422.088	4527.195
8	Max.BM	Comb.	-400.178	4717.344
8	Max.BM	Comb.	-390.103	4717.344
8.41	Max.BM	Comb.	-370.68	4873.3046
8.41	Max.BM	Comb.	-370.68	4873.3046
8.6	Max.BM	Comb.	-361.68	4942.8788
8.6	Max.BM	Comb.	-361.68	4942.8788
9.04	Max.BM	Comb.	-340.836	5097.4321
9.48	Max.BM	Comb.	-319.992	5242.8141
9.92	Max.BM	Comb.	-299.148	5379.0248
10.36	Max.BM	Comb.	-278.304	5506.0641
10.8	Max.BM	Comb.	-257.46	5623.9322
10.8	Max.BM	Comb.	-66.4	5623.9322
11.2	Max.BM	Comb.	-47.451	5646.7024
11.6	Max.BM	Comb.	-28.502	5661.893
12	Max.BM	Comb.	-9.553	5669.504
12	Max.BM	Comb.	181.507	5669.504
12.36	Max.BM	Comb.	198.324	5602.084

Interior girder

TABLE: Element Forces - Frames				
Station(m)	OutputCase	CaseType	V2(KN)	M3(KNm)
0	Max.BM	Comb.	-767.274	3.918E-13
0.4	Max.BM	Comb.	-748.405	303.1356
0.8	Max.BM	Comb.	-729.536	598.7236
1.2	Max.BM	Comb.	-710.667	886.764
1.2	Max.BM	Comb.	-710.667	886.764
1.643	Max.BM	Comb.	-689.776	1196.8619
2.086	Max.BM	Comb.	-668.885	1497.7083
2.529	Max.BM	Comb.	-647.994	1789.3031
2.971	Max.BM	Comb.	-627.104	2071.6463
3.414	Max.BM	Comb.	-606.213	2344.7379
3.857	Max.BM	Comb.	-585.322	2608.5779
4.3	Max.BM	Comb.	-564.432	2863.1663
4.3	Max.BM	Comb.	-564.432	2863.1663
4.763	Max.BM	Comb.	-542.614	3119.1707
5.225	Max.BM	Comb.	-520.797	3365.0847
5.688	Max.BM	Comb.	-498.98	3600.9081
6.15	Max.BM	Comb.	-477.163	3826.6411
6.613	Max.BM	Comb.	-455.345	4042.2836
7.075	Max.BM	Comb.	-433.528	4247.8355
7.538	Max.BM	Comb.	-411.711	4443.297
8	Max.BM	Comb.	-389.894	4628.668
8	Max.BM	Comb.	-369.731	4628.668
8.41	Max.BM	Comb.	-350.39	4776.2929
8.41	Max.BM	Comb.	-350.39	4776.2929
8.6	Max.BM	Comb.	-341.428	4842.0156
8.6	Max.BM	Comb.	-341.428	4842.0156
9.04	Max.BM	Comb.	-320.672	4987.6774
9.48	Max.BM	Comb.	-299.916	5124.2066
9.92	Max.BM	Comb.	-279.16	5251.6032
10.36	Max.BM	Comb.	-258.404	5369.8672
10.8	Max.BM	Comb.	-237.648	5478.9986
10.8	Max.BM	Comb.	-65.228	5478.9986
11.2	Max.BM	Comb.	-46.359	5501.316
11.6	Max.BM	Comb.	-27.49	5516.0858
12	Max.BM	Comb.	-8.621	5523.308
12	Max.BM	Comb.	163.799	5523.308
12.36	Max.BM	Comb.	180.545	5462.1869

12.71	Max.BM	Comb.	215.141	5528.6938	12.71	Max.BM	Comb.	197.291	5395.1209
12.71	Max.BM	Comb.	215.141	5528.6938	12.71	Max.BM	Comb.	197.291	5395.1209
13.18	Max.BM	Comb.	237.407	5422.345	13.18	Max.BM	Comb.	219.463	5297.1837
13.65	Max.BM	Comb.	259.672	5305.5316	13.65	Max.BM	Comb.	241.634	5188.8261
14.12	Max.BM	Comb.	281.937	5178.2537	14.12	Max.BM	Comb.	263.805	5070.0481
14.59	Max.BM	Comb.	304.202	5040.5111	14.59	Max.BM	Comb.	285.976	4940.8497
15.06	Max.BM	Comb.	326.467	4892.304	15.06	Max.BM	Comb.	308.147	4801.2308
15.53	Max.BM	Comb.	348.732	4733.6323	15.53	Max.BM	Comb.	330.318	4651.1916
16	Max.BM	Comb.	370.997	4564.496	16	Max.BM	Comb.	352.489	4490.732
16	Max.BM	Comb.	381.072	4564.496	16	Max.BM	Comb.	372.652	4490.732
16.51	Max.BM	Comb.	404.995	4366.0141	16.51	Max.BM	Comb.	396.474	4296.5279
17.01	Max.BM	Comb.	428.918	4155.4509	17.01	Max.BM	Comb.	420.296	4090.2937
17.01	Max.BM	Comb.	428.918	4155.4509	17.01	Max.BM	Comb.	420.296	4090.2937
17.51	Max.BM	Comb.	452.571	3935.3935	17.51	Max.BM	Comb.	443.848	3874.5663
18.01	Max.BM	Comb.	476.223	3703.5268	18.01	Max.BM	Comb.	467.401	3647.0794
18.51	Max.BM	Comb.	499.875	3459.8508	18.51	Max.BM	Comb.	490.953	3407.8332
19.01	Max.BM	Comb.	523.528	3204.3655	19.01	Max.BM	Comb.	514.506	3156.8274
19.51	Max.BM	Comb.	547.18	2937.0708	19.51	Max.BM	Comb.	538.059	2894.0622
20.01	Max.BM	Comb.	570.833	2657.9669	20.01	Max.BM	Comb.	561.611	2619.5376
20.51	Max.BM	Comb.	594.485	2367.0536	20.51	Max.BM	Comb.	585.164	2333.2535
21	Max.BM	Comb.	618.138	2064.331	21	Max.BM	Comb.	608.716	2035.2099
21.5	Max.BM	Comb.	641.79	1749.7991	21.5	Max.BM	Comb.	632.269	1725.4069
22	Max.BM	Comb.	665.442	1423.4579	22	Max.BM	Comb.	655.821	1403.8444
22.5	Max.BM	Comb.	689.095	1085.3074	22.5	Max.BM	Comb.	679.374	1070.5225
23	Max.BM	Comb.	712.747	735.3476	23	Max.BM	Comb.	702.926	725.4411
23.5	Max.BM	Comb.	736.4	373.5784	23.5	Max.BM	Comb.	726.479	368.6003
24	Max.BM	Comb.	760.052	-6.042E-12	24	Max.BM	Comb.	750.032	-4.279E-12
0	Service BM	Comb.	-536.347	5.116E-13	0	ervice BM	Comb.	-522.189	1.516E-13
0.4	Service BM	Comb.	-522.191	211.7076	0.4	ervice BM	Comb.	-508.437	206.1252
0.8	Service BM	Comb.	-508.035	417.7528	0.8	ervice BM	Comb.	-494.685	406.7496
1.2	Service BM	Comb.	-493.879	618.1356	1.2	ervice BM	Comb.	-480.933	601.8732
1.2	Service BM	Comb.	-384.819	618.1356	1.2	ervice BM	Comb.	-382.513	601.8732
1.643	Service BM	Comb.	-369.146	785.0851	1.643	ervice BM	Comb.	-367.288	767.9005
2.086	Service BM	Comb.	-353.474	945.0937	2.086	ervice BM	Comb.	-352.062	927.185
2.529	Service BM	Comb.	-337.801	1098.1616	2.529	ervice BM	Comb.	-336.837	1079.7269
2.971	Service BM	Comb.	-322.128	1244.2888	2.971	ervice BM	Comb.	-321.611	1225.5261
3.414	Service BM	Comb.	-306.455	1383.4751	3.414	ervice BM	Comb.	-306.386	1364.5826
3.857	Service BM	Comb.	-290.783	1515.7207	3.857	ervice BM	Comb.	-291.16	1496.8965
4.3	Service BM	Comb.	-275.11	1641.0256	4.3	ervice BM	Comb.	-275.935	1622.4676
4.3	Service BM	Comb.	-275.11	1641.0256	4.3	ervice BM	Comb.	-275.935	1622.4676
4.763	Service BM	Comb.	-258.742	1764.4789	4.763	ervice BM	Comb.	-260.034	1746.4105
5.225	Service BM	Comb.	-242.374	1880.362	5.225	ervice BM	Comb.	-244.134	1862.9993
5.688	Service BM	Comb.	-226.006	1988.675	5.688	ervice BM	Comb.	-228.233	1972.234
6.15	Service BM	Comb.	-209.639	2089.4179	6.15	ervice BM	Comb.	-212.332	2074.1146
6.613	Service BM	Comb.	-193.271	2182.5906	6.613	ervice BM	Comb.	-196.431	2168.6411
7.075	Service BM	Comb.	-176.903	2268.1932	7.075	ervice BM	Comb.	-180.531	2255.8135
7.538	Service BM	Comb.	-160.535	2346.2257	7.538	ervice BM	Comb.	-164.63	2335.6318
8	Service BM	Comb.	-144.167	2416.688	8	ervice BM	Comb.	-148.729	2408.096
8	Service BM	Comb.	-136.107	2416.688	8	ervice BM	Comb.	-132.599	2408.096
8.41	Service BM	Comb.	-121.597	2469.5173	8.41	ervice BM	Comb.	-118.503	2459.572
8.41	Service BM	Comb.	-121.597	2469.5173	8.41	ervice BM	Comb.	-118.503	2459.572
8.6	Service BM	Comb.	-114.873	2491.982	8.6	ervice BM	Comb.	-111.971	2481.467
8.6	Service BM	Comb.	-114.873	2491.982	8.6	ervice BM	Comb.	-111.971	2481.467
9.04	Service BM	Comb.	-99.301	2539.1004	9.04	ervice BM	Comb.	-96.844	2527.4063
9.48	Service BM	Comb.	-83.73	2579.3672	9.48	ervice BM	Comb.	-81.717	2566.6895
9.92	Service BM	Comb.	-68.158	2612.7826	9.92	ervice BM	Comb.	-66.589	2599.3169
10.36	Service BM	Comb.	-52.587	2639.3464	10.36	ervice BM	Comb.	-51.462	2625.2882
10.8	Service BM	Comb.	-37.015	2659.0588	10.8	ervice BM	Comb.	-36.335	2644.6036
10.8	Service BM	Comb.	-37.015	2659.0588	10.8	ervice BM	Comb.	-36.335	2644.6036
11.2	Service BM	Comb.	-22.859	2671.0336	11.2	ervice BM	Comb.	-22.583	2656.3872
11.6	Service BM	Comb.	-8.703	2677.346	11.6	ervice BM	Comb.	-8.831	2662.67
12	Service BM	Comb.	5.453	2677.996	12	ervice BM	Comb.	4.921	2663.452

12	Service BM	Comb.	5.453	2677.996	12	Service BM	Comb.	4.921	2663.452
12.36	Service BM	Comb.	18.016	2673.8302	12.36	Service BM	Comb.	17.126	2659.5387
12.71	Service BM	Comb.	30.58	2665.2043	12.71	Service BM	Comb.	29.331	2651.2926
12.71	Service BM	Comb.	30.58	2665.2043	12.71	Service BM	Comb.	29.331	2651.2926
13.18	Service BM	Comb.	47.213	2646.9229	13.18	Service BM	Comb.	45.489	2633.7099
13.65	Service BM	Comb.	63.847	2620.8239	13.65	Service BM	Comb.	61.648	2608.5326
14.12	Service BM	Comb.	80.48	2586.9072	14.12	Service BM	Comb.	77.807	2575.7607
14.59	Service BM	Comb.	97.113	2545.1729	14.59	Service BM	Comb.	93.965	2535.3944
15.06	Service BM	Comb.	113.746	2495.6209	15.06	Service BM	Comb.	110.124	2487.4335
15.53	Service BM	Comb.	130.38	2438.2513	15.53	Service BM	Comb.	126.282	2431.878
16	Service BM	Comb.	147.013	2373.064	16	Service BM	Comb.	142.441	2368.728
16	Service BM	Comb.	155.073	2373.064	16	Service BM	Comb.	158.571	2368.728
16.51	Service BM	Comb.	172.945	2290.2395	16.51	Service BM	Comb.	175.933	2284.2658
17.01	Service BM	Comb.	190.817	2198.3896	17.01	Service BM	Comb.	193.295	2191.0358
17.01	Service BM	Comb.	190.817	2198.3896	17.01	Service BM	Comb.	193.295	2191.0358
17.51	Service BM	Comb.	208.487	2098.7063	17.51	Service BM	Comb.	210.46	2090.2412
18.01	Service BM	Comb.	226.156	1990.2008	18.01	Service BM	Comb.	227.626	1980.8762
18.51	Service BM	Comb.	243.826	1872.8731	18.51	Service BM	Comb.	244.791	1862.9407
19.01	Service BM	Comb.	261.496	1746.7231	19.01	Service BM	Comb.	261.957	1736.4348
19.51	Service BM	Comb.	279.166	1611.7508	19.51	Service BM	Comb.	279.122	1601.3584
20.01	Service BM	Comb.	296.835	1467.9564	20.01	Service BM	Comb.	296.287	1457.7115
20.51	Service BM	Comb.	314.505	1315.3397	20.51	Service BM	Comb.	313.453	1305.4942
21	Service BM	Comb.	332.175	1153.9007	21	Service BM	Comb.	330.618	1144.7064
21.5	Service BM	Comb.	349.844	983.6395	21.5	Service BM	Comb.	347.784	975.3481
22	Service BM	Comb.	367.514	804.5561	22	Service BM	Comb.	364.949	797.4194
22.5	Service BM	Comb.	385.184	616.6504	22.5	Service BM	Comb.	382.115	610.9203
23	Service BM	Comb.	402.854	419.9225	23	Service BM	Comb.	399.28	415.8506
23.5	Service BM	Comb.	420.523	214.3724	23.5	Service BM	Comb.	416.446	212.2105
24	Service BM	Comb.	438.193	-5.187E-12	24	Service BM	Comb.	433.611	-3.169E-12

APPENDIX B

Output from sap2000V14 software

Box Girder Bridge Exterior and Interior analysis

Clear Span length 14m

Exterior girder

TABLE: Element Forces - Frames

Station(m)	OutputCase	CaseType	V2(KN)	M3(KNm)
0	Max. BM	Comb.	-570.083	-3.111E-13
0.4	Max. BM	Comb.	-554.324	224.8813
0.8	Max. BM	Comb.	-538.565	443.459
1.2	Max. BM	Comb.	-522.806	655.7332
1.2	Max. BM	Comb.	-522.806	655.7332
1.642	Max. BM	Comb.	-505.392	882.9649
2.084	Max. BM	Comb.	-487.978	1102.4998
2.526	Max. BM	Comb.	-470.565	1314.3378
2.968	Max. BM	Comb.	-453.151	1518.479
3.41	Max. BM	Comb.	-435.737	1714.9233
3.41	Max. BM	Comb.	-204.834	1714.9233
3.855	Max. BM	Comb.	-187.302	1802.1738
4.3	Max. BM	Comb.	-169.771	1881.6225
4.3	Max. BM	Comb.	-169.771	1881.6225
4.8	Max. BM	Comb.	-150.072	1961.5831
5.3	Max. BM	Comb.	-130.373	2031.6943
5.8	Max. BM	Comb.	-110.674	2091.9561
5.8	Max. BM	Comb.	-110.674	2091.9561
6.2	Max. BM	Comb.	-94.915	2133.0741
6.6	Max. BM	Comb.	-79.156	2167.8884
7	Max. BM	Comb.	-63.397	2196.3991
7	Max. BM	Comb.	-63.397	2196.3991
7.355	Max. BM	Comb.	-49.411	2216.4226
7.71	Max. BM	Comb.	-35.425	2231.481
7.71	Max. BM	Comb.	195.478	2231.481
8.155	Max. BM	Comb.	213.01	2140.5925
8.6	Max. BM	Comb.	230.542	2041.9023
8.6	Max. BM	Comb.	230.542	2041.9023
9.087	Max. BM	Comb.	249.734	1924.9209
9.574	Max. BM	Comb.	268.926	1798.5901
10.06	Max. BM	Comb.	288.118	1662.91
10.55	Max. BM	Comb.	307.311	1517.8806
11.04	Max. BM	Comb.	326.503	1363.5018
11.52	Max. BM	Comb.	345.695	1199.7736
12.01	Max. BM	Comb.	364.887	1026.6961
12.01	Max. BM	Comb.	476.727	1026.6961
12.51	Max. BM	Comb.	496.327	784.6488
13.01	Max. BM	Comb.	515.928	532.8503
13.5	Max. BM	Comb.	535.528	271.3007
14	Max. BM	Comb.	555.128	6.225E-13
0	Service BM	Comb.	-570.083	-3.111E-13
0.4	Service BM	Comb.	-554.324	224.8813
0.8	Service BM	Comb.	-538.565	443.459
1.2	Service BM	Comb.	-522.806	655.7332
1.2	Service BM	Comb.	-522.806	655.7332
1.642	Service BM	Comb.	-505.392	882.9649
2.084	Service BM	Comb.	-487.978	1102.4998
2.526	Service BM	Comb.	-470.565	1314.3378

Interior girder

TABLE: Element Forces - Frames

Station(m)	OutputCase	CaseType	V2(KN)	M3(KNm)
0	Max. BM	Comb.	-593.013	-3.314E-13
0.4	Max. BM	Comb.	-575.684	233.7393
0.8	Max. BM	Comb.	-558.355	460.5469
1.2	Max. BM	Comb.	-541.026	680.423
1.2	Max. BM	Comb.	-541.026	680.423
1.642	Max. BM	Comb.	-521.877	915.3245
2.084	Max. BM	Comb.	-502.729	1141.7623
2.526	Max. BM	Comb.	-483.58	1359.7365
2.968	Max. BM	Comb.	-464.431	1569.247
3.41	Max. BM	Comb.	-445.283	1770.2939
3.41	Max. BM	Comb.	-217.875	1770.2939
3.855	Max. BM	Comb.	-198.596	1862.9588
4.3	Max. BM	Comb.	-179.318	1947.0447
4.3	Max. BM	Comb.	-179.318	1947.0447
4.8	Max. BM	Comb.	-157.657	2031.2883
5.3	Max. BM	Comb.	-135.995	2104.7014
5.8	Max. BM	Comb.	-114.334	2167.2837
5.8	Max. BM	Comb.	-114.334	2167.2837
6.2	Max. BM	Comb.	-97.005	2209.5516
6.6	Max. BM	Comb.	-79.676	2244.8878
7	Max. BM	Comb.	-62.347	2273.2925
7	Max. BM	Comb.	-62.347	2273.2925
7.355	Max. BM	Comb.	-46.968	2292.6959
7.71	Max. BM	Comb.	-31.588	2306.6395
7.71	Max. BM	Comb.	195.82	2306.6395
8.155	Max. BM	Comb.	215.098	2215.2102
8.6	Max. BM	Comb.	234.377	2115.202
8.6	Max. BM	Comb.	234.377	2115.202
9.087	Max. BM	Comb.	255.481	1995.8866
9.574	Max. BM	Comb.	276.585	1866.2904
10.06	Max. BM	Comb.	297.69	1726.4134
10.55	Max. BM	Comb.	318.794	1576.2557
11.04	Max. BM	Comb.	339.898	1415.8171
11.52	Max. BM	Comb.	361.002	1245.0978
12.01	Max. BM	Comb.	382.107	1064.0977
12.01	Max. BM	Comb.	491.617	1064.0977
12.51	Max. BM	Comb.	513.17	814.1572
13.01	Max. BM	Comb.	534.722	553.494
13.5	Max. BM	Comb.	556.275	282.1083
14	Max. BM	Comb.	577.828	-6.735E-13
0	Service BM	Comb.	-593.013	-3.314E-13
0.4	Service BM	Comb.	-575.684	233.7393
0.8	Service BM	Comb.	-558.355	460.5469
1.2	Service BM	Comb.	-541.026	680.423
1.2	Service BM	Comb.	-541.026	680.423
1.642	Service BM	Comb.	-521.877	915.3245
2.084	Service BM	Comb.	-502.729	1141.7623
2.526	Service BM	Comb.	-483.58	1359.7365

2.968	Service BM	Comb.	-453.151	1518.479
3.41	Service BM	Comb.	-435.737	1714.9233
3.41	Service BM	Comb.	-204.834	1714.9233
3.855	Service BM	Comb.	-187.302	1802.1738
4.3	Service BM	Comb.	-169.771	1881.6225
4.3	Service BM	Comb.	-169.771	1881.6225
4.8	Service BM	Comb.	-150.072	1961.5831
5.3	Service BM	Comb.	-130.373	2031.6943
5.8	Service BM	Comb.	-110.674	2091.9561
5.8	Service BM	Comb.	-110.674	2091.9561
6.2	Service BM	Comb.	-94.915	2133.0741
6.6	Service BM	Comb.	-79.156	2167.8884
7	Service BM	Comb.	-63.397	2196.3991
7	Service BM	Comb.	-63.397	2196.3991
7.355	Service BM	Comb.	-49.411	2216.4226
7.71	Service BM	Comb.	-35.425	2231.481
7.71	Service BM	Comb.	195.478	2231.481
8.155	Service BM	Comb.	213.01	2140.5925
8.6	Service BM	Comb.	230.542	2041.9023
8.6	Service BM	Comb.	230.542	2041.9023
9.087	Service BM	Comb.	249.734	1924.9209
9.574	Service BM	Comb.	268.926	1798.5901
10.06	Service BM	Comb.	288.118	1662.91
10.55	Service BM	Comb.	307.311	1517.8806
11.04	Service BM	Comb.	326.503	1363.5018
11.52	Service BM	Comb.	345.695	1199.7736
12.01	Service BM	Comb.	364.887	1026.6961
12.01	Service BM	Comb.	476.727	1026.6961
12.51	Service BM	Comb.	496.327	784.6488
13.01	Service BM	Comb.	515.928	532.8503
13.5	Service BM	Comb.	535.528	271.3007
14	Service BM	Comb.	555.128	6.225E-13

2.968	Service BM	Comb.	-464.431	1569.247
3.41	Service BM	Comb.	-445.283	1770.2939
3.41	Service BM	Comb.	-217.875	1770.2939
3.855	Service BM	Comb.	-198.596	1862.9588
4.3	Service BM	Comb.	-179.318	1947.0447
4.3	Service BM	Comb.	-179.318	1947.0447
4.8	Service BM	Comb.	-157.657	2031.2883
5.3	Service BM	Comb.	-135.995	2104.7014
5.8	Service BM	Comb.	-114.334	2167.2837
5.8	Service BM	Comb.	-114.334	2167.2837
6.2	Service BM	Comb.	-97.005	2209.5516
6.6	Service BM	Comb.	-79.676	2244.8878
7	Service BM	Comb.	-62.347	2273.2925
7	Service BM	Comb.	-62.347	2273.2925
7.355	Service BM	Comb.	-46.968	2292.6959
7.71	Service BM	Comb.	-31.588	2306.6395
7.71	Service BM	Comb.	195.82	2306.6395
8.155	Service BM	Comb.	215.098	2215.2102
8.6	Service BM	Comb.	234.377	2115.202
8.6	Service BM	Comb.	234.377	2115.202
9.087	Service BM	Comb.	255.481	1995.8866
9.574	Service BM	Comb.	276.585	1866.2904
10.06	Service BM	Comb.	297.69	1726.4134
10.55	Service BM	Comb.	318.794	1576.2557
11.04	Service BM	Comb.	339.898	1415.8171
11.52	Service BM	Comb.	361.002	1245.0978
12.01	Service BM	Comb.	382.107	1064.0977
12.01	Service BM	Comb.	491.617	1064.0977
12.51	Service BM	Comb.	513.17	814.1572
13.01	Service BM	Comb.	534.722	553.494
13.5	Service BM	Comb.	556.275	282.1083
14	Service BM	Comb.	577.828	-6.735E-13

Box Girder Bridge Exterior and Interior analysis

Clear Span length 18m

Exterior girder

TABLE: Element Forces - Frames

Station(m)	OutputCase	CaseType	V2(KN)	M3(KNm)
0	Max. BM	Comb.	-554.478	2.025E-13
0.4	Max. BM	Comb.	-538.119	218.5192
0.8	Max. BM	Comb.	-521.76	430.4948
1.2	Max. BM	Comb.	-505.401	635.9268
1.2	Max. BM	Comb.	-505.401	635.9268
1.643	Max. BM	Comb.	-487.289	855.7366
2.086	Max. BM	Comb.	-469.177	1067.5254
2.529	Max. BM	Comb.	-451.065	1271.2933
2.971	Max. BM	Comb.	-432.954	1467.0403
3.414	Max. BM	Comb.	-414.842	1654.7664
3.857	Max. BM	Comb.	-396.73	1834.4716
4.3	Max. BM	Comb.	-378.618	2006.1559
4.3	Max. BM	Comb.	-378.618	2006.1559
4.67	Max. BM	Comb.	-363.486	2143.4452
5.04	Max. BM	Comb.	-348.354	2275.1356
5.41	Max. BM	Comb.	-333.222	2401.2272
5.41	Max. BM	Comb.	-333.222	2401.2272
5.888	Max. BM	Comb.	-313.673	2555.8351
6.366	Max. BM	Comb.	-294.124	2701.0986
6.844	Max. BM	Comb.	-274.575	2837.0177
7.322	Max. BM	Comb.	-255.026	2963.5923

Interior girder

TABLE: Element Forces - Frames

Station(m)	OutputCase	CaseType	V2(KN)	M3(KNm)
0	Max. BM	Comb.	-587.272	1.609E-13
0.4	Max. BM	Comb.	-569.345	231.3235
0.8	Max. BM	Comb.	-551.418	455.4761
1.2	Max. BM	Comb.	-533.491	672.458
1.2	Max. BM	Comb.	-533.491	672.458
1.643	Max. BM	Comb.	-513.643	904.3235
2.086	Max. BM	Comb.	-493.796	1127.3993
2.529	Max. BM	Comb.	-473.948	1341.6854
2.971	Max. BM	Comb.	-454.1	1547.1818
3.414	Max. BM	Comb.	-434.252	1743.8884
3.857	Max. BM	Comb.	-414.405	1931.8053
4.3	Max. BM	Comb.	-394.557	2110.9325
4.3	Max. BM	Comb.	-394.557	2110.9325
4.67	Max. BM	Comb.	-377.974	2253.8508
5.04	Max. BM	Comb.	-361.392	2390.6336
5.41	Max. BM	Comb.	-344.809	2521.2809
5.41	Max. BM	Comb.	-344.809	2521.2809
5.888	Max. BM	Comb.	-323.387	2680.9798
6.366	Max. BM	Comb.	-301.964	2830.4386
6.844	Max. BM	Comb.	-280.541	2969.6573
7.322	Max. BM	Comb.	-259.118	3098.636

7.8	Max. BM	Comb.	-235.477	3080.8226	7.8	Max. BM	Comb.	-237.696	3217.3746
7.8	Max. BM	Comb.	-60.727	3080.8226	7.8	Max. BM	Comb.	-65.276	3217.3746
8.2	Max. BM	Comb.	-44.368	3101.8416	8.2	Max. BM	Comb.	-47.349	3239.8994
8.6	Max. BM	Comb.	-28.009	3116.317	8.6	Max. BM	Comb.	-29.422	3255.2535
8.6	Max. BM	Comb.	-28.009	3116.317	8.6	Max. BM	Comb.	-29.422	3255.2535
9	Max. BM	Comb.	-11.65	3124.2488	9	Max. BM	Comb.	-11.495	3263.4368
9	Max. BM	Comb.	163.1	3124.2488	9	Max. BM	Comb.	160.925	3263.4368
9.355	Max. BM	Comb.	177.619	3063.7712	9.355	Max. BM	Comb.	176.836	3203.4842
9.71	Max. BM	Comb.	192.137	2998.1395	9.71	Max. BM	Comb.	192.746	3137.8835
9.71	Max. BM	Comb.	192.137	2998.1395	9.71	Max. BM	Comb.	192.746	3137.8835
10.19	Max. BM	Comb.	211.677	2901.6728	10.19	Max. BM	Comb.	214.159	3040.6786
10.67	Max. BM	Comb.	231.217	2795.8703	10.67	Max. BM	Comb.	235.571	2933.2431
11.14	Max. BM	Comb.	250.757	2680.732	11.14	Max. BM	Comb.	256.984	2815.5771
11.62	Max. BM	Comb.	270.297	2556.258	11.62	Max. BM	Comb.	278.397	2687.6805
12.1	Max. BM	Comb.	289.837	2422.4483	12.1	Max. BM	Comb.	299.81	2549.5533
12.58	Max. BM	Comb.	309.377	2279.3029	12.58	Max. BM	Comb.	321.223	2401.1955
13.05	Max. BM	Comb.	328.917	2126.8217	13.05	Max. BM	Comb.	342.635	2242.6072
13.53	Max. BM	Comb.	348.457	1965.0047	13.53	Max. BM	Comb.	364.048	2073.7884
14.01	Max. BM	Comb.	367.996	1793.8521	14.01	Max. BM	Comb.	385.461	1894.739
14.01	Max. BM	Comb.	367.996	1793.8521	14.01	Max. BM	Comb.	385.461	1894.739
14.51	Max. BM	Comb.	388.394	1605.2272	14.51	Max. BM	Comb.	407.814	1696.9161
15.01	Max. BM	Comb.	408.792	1406.429	15.01	Max. BM	Comb.	430.166	1487.9448
15.51	Max. BM	Comb.	429.189	1197.4574	15.51	Max. BM	Comb.	452.519	1267.825
16.01	Max. BM	Comb.	449.587	978.3126	16.01	Max. BM	Comb.	474.872	1036.5569
16.5	Max. BM	Comb.	469.985	748.9944	16.5	Max. BM	Comb.	497.225	794.1403
17	Max. BM	Comb.	490.382	509.5029	17	Max. BM	Comb.	519.577	540.5753
17.5	Max. BM	Comb.	510.78	259.8381	17.5	Max. BM	Comb.	541.93	275.8619
18	Max. BM	Comb.	531.178	-6.929E-13	18	Max. BM	Comb.	564.283	-7.747E-13
0	Service BM	Comb.	-438.933	1.492E-13	0	Service BM	Comb.	-456.898	8.981E-14
0.4	Service BM	Comb.	-426.849	173.1563	0.4	Service BM	Comb.	-443.899	180.1594
0.8	Service BM	Comb.	-414.765	341.4789	0.8	Service BM	Comb.	-430.901	355.1194
1.2	Service BM	Comb.	-402.681	504.968	1.2	Service BM	Comb.	-417.902	524.8801
1.2	Service BM	Comb.	-402.681	504.968	1.2	Service BM	Comb.	-417.902	524.8801
1.643	Service BM	Comb.	-389.302	680.3356	1.643	Service BM	Comb.	-403.511	706.7646
2.086	Service BM	Comb.	-375.923	849.7783	2.086	Service BM	Comb.	-389.12	882.2759
2.529	Service BM	Comb.	-362.545	1013.2962	2.529	Service BM	Comb.	-374.729	1051.414
2.971	Service BM	Comb.	-349.166	1170.8892	2.971	Service BM	Comb.	-360.338	1214.1789
3.414	Service BM	Comb.	-335.787	1322.5574	3.414	Service BM	Comb.	-345.947	1370.5706
3.857	Service BM	Comb.	-322.408	1468.3006	3.857	Service BM	Comb.	-331.556	1520.5891
4.3	Service BM	Comb.	-309.03	1608.1191	4.3	Service BM	Comb.	-317.165	1664.2344
4.3	Service BM	Comb.	-309.03	1608.1191	4.3	Service BM	Comb.	-317.165	1664.2344
4.67	Service BM	Comb.	-297.852	1720.3922	4.67	Service BM	Comb.	-305.141	1779.3611
5.04	Service BM	Comb.	-286.674	1828.5295	5.04	Service BM	Comb.	-293.118	1890.039
5.41	Service BM	Comb.	-275.497	1932.5311	5.41	Service BM	Comb.	-281.094	1996.2683
5.41	Service BM	Comb.	-143.694	1932.5311	5.41	Service BM	Comb.	-151.286	1996.2683
5.888	Service BM	Comb.	-129.253	1997.7654	5.888	Service BM	Comb.	-135.753	2064.8707
6.366	Service BM	Comb.	-114.813	2056.0972	6.366	Service BM	Comb.	-120.22	2126.0483
6.844	Service BM	Comb.	-100.372	2107.5265	6.844	Service BM	Comb.	-104.687	2179.8012
7.322	Service BM	Comb.	-85.932	2152.0533	7.322	Service BM	Comb.	-89.154	2226.1292
7.8	Service BM	Comb.	-71.492	2189.6775	7.8	Service BM	Comb.	-73.621	2265.0323
7.8	Service BM	Comb.	-71.492	2189.6775	7.8	Service BM	Comb.	-73.621	2265.0323
8.2	Service BM	Comb.	-59.408	2215.8574	8.2	Service BM	Comb.	-60.622	2291.881
8.6	Service BM	Comb.	-47.324	2237.2037	8.6	Service BM	Comb.	-47.624	2313.5303
8.6	Service BM	Comb.	-47.324	2237.2037	8.6	Service BM	Comb.	-47.624	2313.5303
9	Service BM	Comb.	-35.24	2253.7164	9	Service BM	Comb.	-34.626	2329.9803
9	Service BM	Comb.	-35.24	2253.7164	9	Service BM	Comb.	-34.626	2329.9803
9.355	Service BM	Comb.	-24.515	2264.3228	9.355	Service BM	Comb.	-23.09	2340.2247
9.71	Service BM	Comb.	-13.791	2271.1221	9.71	Service BM	Comb.	-11.554	2346.3739
9.71	Service BM	Comb.	118.012	2271.1221	9.71	Service BM	Comb.	118.254	2346.3739
10.19	Service BM	Comb.	132.446	2211.2903	10.19	Service BM	Comb.	133.78	2286.1655
10.67	Service BM	Comb.	146.88	2144.5625	10.67	Service BM	Comb.	149.306	2218.5393
11.14	Service BM	Comb.	161.313	2070.9386	11.14	Service BM	Comb.	164.832	2143.4951

11.62	Service BM	Comb.	175.747	1990.4186	11.62	Service BM	Comb.	180.358	2061.0331
12.1	Service BM	Comb.	190.181	1903.0025	12.1	Service BM	Comb.	195.884	1971.1531
12.58	Service BM	Comb.	204.614	1808.6903	12.58	Service BM	Comb.	211.41	1873.8552
13.05	Service BM	Comb.	219.048	1707.482	13.05	Service BM	Comb.	226.936	1769.1394
13.53	Service BM	Comb.	233.482	1599.3777	13.53	Service BM	Comb.	242.461	1657.0056
14.01	Service BM	Comb.	247.915	1484.3772	14.01	Service BM	Comb.	257.987	1537.454
14.01	Service BM	Comb.	311.755	1484.3772	14.01	Service BM	Comb.	320.497	1537.454
14.51	Service BM	Comb.	326.823	1325.1318	14.51	Service BM	Comb.	336.705	1373.5643
15.01	Service BM	Comb.	341.89	1158.3716	15.01	Service BM	Comb.	352.912	1201.5911
15.51	Service BM	Comb.	356.957	984.0967	15.51	Service BM	Comb.	369.119	1021.5345
16.01	Service BM	Comb.	372.024	802.3069	16.01	Service BM	Comb.	385.327	833.3944
16.5	Service BM	Comb.	387.092	613.0023	16.5	Service BM	Comb.	401.534	637.171
17	Service BM	Comb.	402.159	416.183	17	Service BM	Comb.	417.742	432.8641
17.5	Service BM	Comb.	417.226	211.8489	17.5	Service BM	Comb.	433.949	220.4738
18	Service BM	Comb.	432.293	-1.718E-12	18	Service BM	Comb.	450.156	1.777E-12

Box Girder Bridge Exterior and Interior analysis

Clear Span length 24m

Exterior girder

TABLE: Element Forces - Frames

Station(m)	OutputCase	CaseType	V2(KN)	M3(KNm)
0	Max.BM	Comb.	-710.318	5.161E-13
0.4	Max.BM	Comb.	-692.757	280.6148
0.8	Max.BM	Comb.	-675.196	554.2052
1.2	Max.BM	Comb.	-657.635	820.7712
1.2	Max.BM	Comb.	-657.635	820.7712
1.643	Max.BM	Comb.	-638.192	1107.7042
2.086	Max.BM	Comb.	-618.749	1386.0269
2.529	Max.BM	Comb.	-599.307	1655.7394
2.971	Max.BM	Comb.	-579.864	1916.8416
3.414	Max.BM	Comb.	-560.422	2169.3336
3.857	Max.BM	Comb.	-540.979	2413.2152
4.3	Max.BM	Comb.	-521.537	2648.4866
4.3	Max.BM	Comb.	-521.537	2648.4866
4.757	Max.BM	Comb.	-501.488	2882.0773
5.213	Max.BM	Comb.	-481.439	3106.5123
5.67	Max.BM	Comb.	-461.39	3321.7917
6.127	Max.BM	Comb.	-441.342	3527.9155
6.583	Max.BM	Comb.	-421.293	3724.8836
7.04	Max.BM	Comb.	-401.244	3912.6961
7.497	Max.BM	Comb.	-381.195	4091.353
7.953	Max.BM	Comb.	-361.146	4260.8543
8.41	Max.BM	Comb.	-341.097	4421.2
8.41	Max.BM	Comb.	-341.097	4421.2
8.6	Max.BM	Comb.	-332.756	4485.2161
8.6	Max.BM	Comb.	-332.756	4485.2161
9.04	Max.BM	Comb.	-313.439	4627.3789
9.48	Max.BM	Comb.	-294.122	4761.0423
9.92	Max.BM	Comb.	-274.805	4886.2061
10.36	Max.BM	Comb.	-255.488	5002.8704
10.8	Max.BM	Comb.	-236.171	5111.0352
10.8	Max.BM	Comb.	-61.42	5111.0352
11.2	Max.BM	Comb.	-43.859	5132.0912
11.6	Max.BM	Comb.	-26.298	5146.1228
12	Max.BM	Comb.	-8.737	5153.13
12	Max.BM	Comb.	166.013	5153.13
12.36	Max.BM	Comb.	181.598	5091.4292
12.71	Max.BM	Comb.	197.183	5024.1955
12.71	Max.BM	Comb.	197.183	5024.1955

Interior girder

TABLE: Element Forces - Frames

Station(m)	OutputCase	CaseType	V2(KN)	M3(KNm)
0	Max.BM	Comb.	-756.432	2.416E-13
0.4	Max.BM	Comb.	-737.305	298.7472
0.8	Max.BM	Comb.	-718.178	589.8436
1.2	Max.BM	Comb.	-699.051	873.2892
1.2	Max.BM	Comb.	-699.051	873.2892
1.643	Max.BM	Comb.	-677.874	1178.1797
2.086	Max.BM	Comb.	-656.698	1473.6921
2.529	Max.BM	Comb.	-635.522	1759.8264
2.971	Max.BM	Comb.	-614.345	2036.5826
3.414	Max.BM	Comb.	-593.169	2303.9607
3.857	Max.BM	Comb.	-571.993	2561.9608
4.3	Max.BM	Comb.	-550.816	2810.5827
4.3	Max.BM	Comb.	-550.816	2810.5827
4.757	Max.BM	Comb.	-528.98	3057.1361
5.213	Max.BM	Comb.	-507.143	3293.7174
5.67	Max.BM	Comb.	-485.306	3520.3267
6.127	Max.BM	Comb.	-463.47	3736.9639
6.583	Max.BM	Comb.	-441.633	3943.629
7.04	Max.BM	Comb.	-419.796	4140.322
7.497	Max.BM	Comb.	-397.96	4327.0429
7.953	Max.BM	Comb.	-376.123	4503.7918
8.41	Max.BM	Comb.	-354.286	4670.5686
8.41	Max.BM	Comb.	-354.286	4670.5686
8.6	Max.BM	Comb.	-345.201	4737.0199
8.6	Max.BM	Comb.	-345.201	4737.0199
9.095	Max.BM	Comb.	-321.531	4902.0362
9.59	Max.BM	Comb.	-297.862	5055.3359
10.09	Max.BM	Comb.	-274.192	5196.9192
10.58	Max.BM	Comb.	-250.522	5326.786
10.58	Max.BM	Comb.	-78.102	5326.786
11.05	Max.BM	Comb.	-55.469	5358.3979
11.53	Max.BM	Comb.	-32.835	5379.2965
12	Max.BM	Comb.	-10.202	5389.4818
12	Max.BM	Comb.	162.218	5389.4818
12.36	Max.BM	Comb.	179.194	5328.8811
12.71	Max.BM	Comb.	196.169	5262.2543
12.71	Max.BM	Comb.	196.169	5262.2543
13.19	Max.BM	Comb.	219.015	5163.0714

13.19	Max.BM	Comb.	218.159	4924.9749	13.67	Max.BM	Comb.	241.861	5052.9732
13.67	Max.BM	Comb.	239.135	4815.7325	14.14	Max.BM	Comb.	264.707	4931.9596
14.14	Max.BM	Comb.	260.11	4696.4685	14.62	Max.BM	Comb.	287.553	4800.0307
14.62	Max.BM	Comb.	281.086	4567.1828	15.1	Max.BM	Comb.	310.4	4657.1863
15.1	Max.BM	Comb.	302.061	4427.8754	15.58	Max.BM	Comb.	333.246	4503.4266
15.58	Max.BM	Comb.	323.037	4278.5463	16.05	Max.BM	Comb.	356.092	4338.7515
16.05	Max.BM	Comb.	344.013	4119.1955	16.53	Max.BM	Comb.	378.938	4163.161
16.53	Max.BM	Comb.	364.988	3949.823	17.01	Max.BM	Comb.	401.784	3976.6552
17.01	Max.BM	Comb.	385.964	3770.4288	17.01	Max.BM	Comb.	401.784	3976.6552
17.01	Max.BM	Comb.	385.964	3770.4288	17.51	Max.BM	Comb.	425.659	3770.09
17.51	Max.BM	Comb.	407.884	3572.2503	18.01	Max.BM	Comb.	449.533	3551.6045
18.01	Max.BM	Comb.	429.804	3363.1276	18.51	Max.BM	Comb.	473.408	3321.1988
18.51	Max.BM	Comb.	451.724	3143.0605	19.01	Max.BM	Comb.	497.283	3078.8729
19.01	Max.BM	Comb.	473.644	2912.0492	19.51	Max.BM	Comb.	521.157	2824.6267
19.51	Max.BM	Comb.	495.563	2670.0936	20.01	Max.BM	Comb.	545.032	2558.4602
20.01	Max.BM	Comb.	517.483	2417.1937	20.51	Max.BM	Comb.	568.906	2280.3736
20.51	Max.BM	Comb.	539.403	2153.3495	21	Max.BM	Comb.	592.781	1990.3666
21	Max.BM	Comb.	561.323	1878.561	21.5	Max.BM	Comb.	616.656	1688.4395
21.5	Max.BM	Comb.	583.243	1592.8282	22	Max.BM	Comb.	640.53	1374.5921
22	Max.BM	Comb.	605.163	1296.1511	22.5	Max.BM	Comb.	664.405	1048.8244
22.5	Max.BM	Comb.	627.083	988.5298	23	Max.BM	Comb.	688.279	711.1365
23	Max.BM	Comb.	649.003	669.9641	23.5	Max.BM	Comb.	712.154	361.5284
23.5	Max.BM	Comb.	670.923	340.4542	24	Max.BM	Comb.	736.028	-5.177E-12
24	Max.BM	Comb.	692.843	-6.585E-12	0	Service BM	Comb.	-512.251	1.374E-13
0	Service BM	Comb.	-486.131	2.984E-13	0.4	Service BM	Comb.	-498.293	202.1087
0.4	Service BM	Comb.	-473.085	191.8431	0.8	Service BM	Comb.	-484.334	398.6341
0.8	Service BM	Comb.	-460.039	378.4679	1.2	Service BM	Comb.	-470.376	589.5761
1.2	Service BM	Comb.	-446.994	559.8745	1.2	Service BM	Comb.	-371.956	589.5761
1.2	Service BM	Comb.	-347.244	559.8745	1.643	Service BM	Comb.	-356.502	750.8774
1.643	Service BM	Comb.	-332.8	710.4557	2.086	Service BM	Comb.	-341.048	905.3349
2.086	Service BM	Comb.	-318.357	854.6406	2.529	Service BM	Comb.	-325.594	1052.9484
2.529	Service BM	Comb.	-303.914	992.4291	2.971	Service BM	Comb.	-310.14	1193.7181
2.971	Service BM	Comb.	-289.47	1123.8212	3.414	Service BM	Comb.	-294.686	1327.6439
3.414	Service BM	Comb.	-275.027	1248.8171	3.857	Service BM	Comb.	-279.232	1454.7258
3.857	Service BM	Comb.	-260.584	1367.4166	4.3	Service BM	Comb.	-263.778	1574.9638
4.3	Service BM	Comb.	-246.14	1479.6197	4.3	Service BM	Comb.	-263.778	1574.9638
4.3	Service BM	Comb.	-246.14	1479.6197	4.757	Service BM	Comb.	-247.842	1691.7838
4.757	Service BM	Comb.	-231.247	1588.6231	5.213	Service BM	Comb.	-231.907	1801.3265
5.213	Service BM	Comb.	-216.353	1690.8249	5.67	Service BM	Comb.	-215.971	1903.5918
5.67	Service BM	Comb.	-201.459	1786.2253	6.127	Service BM	Comb.	-200.035	1998.5797
6.127	Service BM	Comb.	-186.565	1874.8243	6.583	Service BM	Comb.	-184.099	2086.2903
6.583	Service BM	Comb.	-171.672	1956.6217	7.04	Service BM	Comb.	-168.163	2166.7234
7.04	Service BM	Comb.	-156.778	2031.6177	7.497	Service BM	Comb.	-152.227	2239.8793
7.497	Service BM	Comb.	-141.884	2099.8122	7.953	Service BM	Comb.	-136.291	2305.7577
7.953	Service BM	Comb.	-126.99	2161.2053	8.41	Service BM	Comb.	-120.356	2364.3588
8.41	Service BM	Comb.	-112.097	2215.7969	8.41	Service BM	Comb.	-120.356	2364.3588
8.41	Service BM	Comb.	-112.097	2215.7969	8.6	Service BM	Comb.	-113.725	2386.5965
8.6	Service BM	Comb.	-105.9	2236.5066	8.6	Service BM	Comb.	-113.725	2386.5965
8.6	Service BM	Comb.	-105.9	2236.5066	9.095	Service BM	Comb.	-96.452	2438.6154
9.04	Service BM	Comb.	-91.55	2279.9456	9.59	Service BM	Comb.	-79.178	2482.0839
9.48	Service BM	Comb.	-77.2	2317.0705	10.09	Service BM	Comb.	-61.905	2517.002
9.92	Service BM	Comb.	-62.85	2347.8814	10.58	Service BM	Comb.	-44.631	2543.3697
10.36	Service BM	Comb.	-48.499	2372.3782	10.58	Service BM	Comb.	-44.631	2543.3697
10.8	Service BM	Comb.	-34.149	2390.5609	11.05	Service BM	Comb.	-28.114	2560.586
10.8	Service BM	Comb.	-34.149	2390.5609	11.53	Service BM	Comb.	-11.596	2569.9841
11.2	Service BM	Comb.	-21.104	2401.6115	12	Service BM	Comb.	4.921	2571.564
11.6	Service BM	Comb.	-8.058	2407.4439	12	Service BM	Comb.	4.921	2571.564
12	Service BM	Comb.	4.988	2408.058	12.36	Service BM	Comb.	17.309	2567.6182
12	Service BM	Comb.	4.988	2408.058	12.71	Service BM	Comb.	29.697	2559.2746
12.36	Service BM	Comb.	16.565	2404.2323	12.71	Service BM	Comb.	29.697	2559.2746
12.71	Service BM	Comb.	28.143	2396.2965	13.19	Service BM	Comb.	46.37	2541.103
12.71	Service BM	Comb.	28.143	2396.2965	13.67	Service BM	Comb.	63.042	2514.9657

13.19	Service BM	Comb.	43.726	2379.1278	14.14	Service BM	Comb.	79.715	2480.8627
13.67	Service BM	Comb.	59.308	2354.5142	14.62	Service BM	Comb.	96.387	2438.7939
14.14	Service BM	Comb.	74.89	2322.4558	15.1	Service BM	Comb.	113.06	2388.7593
14.62	Service BM	Comb.	90.472	2282.9525	15.58	Service BM	Comb.	129.732	2330.7589
15.1	Service BM	Comb.	106.055	2236.0043	16.05	Service BM	Comb.	146.405	2264.7928
15.58	Service BM	Comb.	121.637	2181.6114	16.53	Service BM	Comb.	163.077	2190.8609
16.05	Service BM	Comb.	137.219	2119.7735	17.01	Service BM	Comb.	179.75	2108.9632
16.53	Service BM	Comb.	152.801	2050.4908	17.01	Service BM	Comb.	179.75	2108.9632
17.01	Service BM	Comb.	168.384	1973.7633	17.51	Service BM	Comb.	197.173	2014.8671
17.01	Service BM	Comb.	168.384	1973.7633	18.01	Service BM	Comb.	214.596	1912.0719
17.51	Service BM	Comb.	184.667	1885.6266	18.51	Service BM	Comb.	232.019	1800.5776
18.01	Service BM	Comb.	200.951	1789.3598	19.01	Service BM	Comb.	249.442	1680.3842
18.51	Service BM	Comb.	217.235	1684.9627	19.51	Service BM	Comb.	266.865	1551.4917
19.01	Service BM	Comb.	233.518	1572.4353	20.01	Service BM	Comb.	284.288	1413.9001
19.51	Service BM	Comb.	249.802	1451.7778	20.51	Service BM	Comb.	301.711	1267.6094
20.01	Service BM	Comb.	266.086	1322.99	21	Service BM	Comb.	319.135	1112.6196
20.51	Service BM	Comb.	282.37	1186.0721	21.5	Service BM	Comb.	336.558	948.9307
21	Service BM	Comb.	298.653	1041.0239	22	Service BM	Comb.	353.981	776.5428
21.5	Service BM	Comb.	314.937	887.8454	22.5	Service BM	Comb.	371.404	595.4557
22	Service BM	Comb.	331.221	726.5368	23	Service BM	Comb.	388.827	405.6696
22.5	Service BM	Comb.	347.504	557.0979	23.5	Service BM	Comb.	406.25	207.1843
23	Service BM	Comb.	363.788	379.5288	24	Service BM	Comb.	423.673	-3.367E-12
23.5	Service BM	Comb.	380.072	193.8295					
24	Service BM	Comb.	396.356	-4.471E-12					